Producer Led Trials

A guide for winegrape producers and service providers

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Acknowledgement of Country

We acknowledge the palawa/pakana people, the Traditional Custodians of the land upon which we live and work. We honour their enduring culture and knowledges as vital to the self-determination, wellbeing and resilience of their communities. We acknowledge their continuing connection to land and sea, waters, environment and community. We pay our respects to their culture, and their Elders past and present.

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Dedication

This publication is dedicated to Dr David Page (1980–2024) who worked tirelessly and meticulously to facilitate some of the case studies for this manual. All who worked with David warmed to him immediately and responded in-kind to his infectious calls to action. To receive a 'high five' from David was the greatest gift and a lesson to us all on how to celebrate achievements both big and small.

Contents

Foreword

It is our pleasure to welcome you to this new and exciting resource: *Producer Led Trials. A guide for winegrape producers and service providers.*

Producer, farmer, grower – whatever term is used it is well known that those who grow our food and fibre like to try new approaches, test new ideas and explore how their crops respond to new or altered inputs. It is not uncommon to hear a producer who has managed the same area of land for decades to say something to the effect "I've been running a 40-year trial!"

Change is constant and arguably accelerating due to climate and dynamic market conditions. Producers can no longer afford to take decades to slowly adapt and optimise practices. Effective trials can give confidence in commercial decisions that in turn contribute to business profitability, sustainability and resilience.

This Guide is for those seeking more effective and efficient ways to conduct an in-vineyard trial that integrates well with existing operations and supports commercial decisions. The approach is purposefully producer-centric and highlights opportunities to access expertise when needed.

This resource had its genesis from the findings of multiple research projects and case studies, which provided the space and time to develop and test the approach outlined in this guide with winegrape producers. The most recent project - the so-called *Botrytis Project* (ADF001) - was funded by the Tasmanian Government's Agricultural Development Fund and led by the Tasmanian Institute of Agriculture (TIA) at the University of Tasmania in partnership with Wine Tasmania and wine businesses operating in Tasmania.

Support from the TAS Farm Innovation Hub enabled the creation of this guide to take the approach from participatory research to a freely available and accessible resource. The Hub and TIA are committed to enabling farmers to be more prepared for drought and climate variability. Recognising and supporting farmer-led experimentation and adaptation is central to meeting this challenge.

We sincerely hope you find this resource useful, usable and relevant to your needs. The approach should be readily adaptable to other types of row crops. Please contact the Tasmanian Institute of Agriculture if you are interested in exploring or extending the opportunities revealed here.

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Kathy has worked for over 35 years with farmers as participants in and beneficiaries of her research. A graduate in Agricultural Science (Melbourne), Kathy worked in country Victoria doing private-sector R&D before post-graduate training in plant pathology in the USA and doctoral and post-doctoral research within two Cooperative Research Centres at the University of Adelaide. She then carved an academic niche at the University of Tasmania through research and extension on plant disease epidemiology and management - work that is recognised nationally and internationally. An avid enabler of change, Kathy has used her various leadership roles at TIA to help research teams develop systems thinking and approaches for better outcomes. A major achievement was leading the successful bid and start-up phase of the TAS Farm Innovation Hub.

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Introduction

This Guide contains four learning modules with step-by-step instructions, resources and case studies from multiple states in Australia on how to conduct simple and informative in-vineyard trials. It is primarily for people who manage vineyards and those providing technical services to wine businesses. Service providers include in-house technical viticulturists, agronomists, consultants and/or private or institutional providers of R&D (research and development) services.

Why this Guide? What's in it for me?

Imagine the scenario where a producer applies a new biological or chemical fungicide over a large area and concludes that the new product works well because a healthy crop is produced. This conclusion may be erroneous if conditions during the growing season had been relatively benign for disease development. Without a rigorous and efficient process to test new approaches across a range of seasonal conditions, then the producer will likely be confined to 'trial and error' over more years than may be necessary to find an answer. Given changes in climate and markets conditions, producers can no longer afford to spend years slowly adapting and improving their practices.

Information from effective in-vineyard trials can support decisions about small or large changes to vineyard operations while helping producers learn more about their production sites. However, conducting a trial means investing time and resources that could be applied elsewhere on the vineyard. Trials must therefore deliver timely information relevant to business needs, a practical outcome and a return on investment. If not, then trial results may be inconclusive, confounded or, at worst, a complete waste of time and money.

This Guide is about helping producers achieve a return on investment from trials in which they have ownership. This means striking a balance between trial rigour and producing commercially relevant results that apply to existing vineyard operations. Producers want to know by how much a crop variable (e.g. yield, disease severity) changes due their actions and are less interested in the statistics used by researchers. Nonetheless, they want confidence in results that they can interpret according to site characteristics and available solutions.

How is it different?

It is important to differentiate the methods described here from other types of on-farm trials. For example, some approaches encourage growers to adopt the replicated trial methods of researchers, whereas others are non-replicated demonstration trials designed to help growers learn about a new practice or technology. Then there are the things that growers try or tinker with at various scales, with or without replication in time or space. Our approach is to purposefully bridge the gap between researcher-led trials and on-farm tinkering; that is, a trial that has both rigour and relevance.

The key principle for this Guide is that the trial is directed at farm business decision-making rather than scientific advancement. The trial layout, an adaptation of the simple strip trial, has the simplicity of a non-replicated demonstration trial yet differs in the way observations are made and presented so that the producer has confidence in easy-to-understand results.

The intent is to minimise the collection of unnecessary data. Moreover, the way data are collected and analysed encourages exploration of spatial variability in the crop's response to treatment. Such knowledge can reveal the potential for differential management (or harvesting) of vines to achieve fruit yield and quality for desired wine styles.

Unlike some other trial types, the questions to be answered by the trial are aligned to individual production goals. The producer also has ownership in the process and decides the degree to which help is sought to plan and implement the trial, and/or to interpret the results. The producer-centric process means that it is not led by a researcher or crop-input supplier. Nonetheless, service providers may adopt methods described here to fully understand how a new practice or technology works in a commercial setting.

Modules

This Guide contains four learning modules that are book ended with key points, templates and/or resources. The templates are intended to prompt thinking and/or provide ideas for standard operating procedures (trial planning, data capture or reporting) that a wine business might develop or adapt to suit their specific operating context and digital recording systems.

The key steps during trial planning and implementation (Modules One and Two) are summarised in the Quick guide.

MODULE 1

How do I plan a trial successfully?

This first module describes the lifecycle of a trial, how to develop a suitable trial question, where to position the trial, and consideration of what actions will be taken, when and by whom. Much attention is given to trial planning so that the trial fits well with existing operations and available resources, costs and risks are minimised, and the results deliver information that is useful, useable and relevant.

MODULE 2

How do I implement a trial successfully?

This module describes how to mark out the trial, implement crop treatments, gather crop observations and measurements, compile and interpret trial results, draw conclusions and plan the next steps based on trial results.

MODULE 3

I'm a service provider. How can I help?

This module provides practical tips and hints for service providers so that they can be effective in providing support and services to producers as they plan and implement a trial.

MODULE 4

How can digital tools add value?

This future-focussed module provides case studies to illustrate how digital tools, especially those used for precision viticulture, can aid the positioning of trial strips, introduce efficiencies in data collection and/or contribute to rigorous interpretation of trial results.

We hope you enjoy using this Guide and find value in the information provided.

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Quick guide

Here are the key concepts and steps during trial planning and implementation. Read the content of Modules 1 and 2 to gain the most from these highly summarised steps.

Q.1 Key concepts

Crop response	Is the change in crop yield or other crop attribute after applying a particular management practice, e.g. a fungicide, compost or a canopy manipulation.
Current practice	Is the way the vines are cultivated and managed in the vineyard block and growing season in which the trial is being conducted. Current practice may change over time, with or without trials.
Test treatment	Is a new or modified practice that is being tested through the conduct of a trial.
Trial site	Is the area in a vineyard block allocated for the conduct of a trial.
Trial strip	Is one or more entire rows in a vineyard block where the vines are managed uniformly, either as 'current practice' or the 'test treatment'.
Vineyard block	Is an area of a single variety of grapevines within a vineyard that is managed uniformly.

Key principle of trial positioning

Vineyard rows selected for trial strips are those likely to capture the maximum range of the crop's response to treatment. This means that when the crop is measured, both high, low and near-average values of the crop measure (e.g. yield, disease severity) are observed in the trial strip. The trial strip is positioned to encompass rather than minimise spatial variability in the crop's response.

Q.2 Trial purpose

1. Describe the viticultural issue, that if addressed, would help you reach your production goals. Would one or more trials help you answer questions about managing this issue?
2. Set the question for the trial. The answer to the question should be 'yes' or 'no' at any given location in the vineyard block. For example: *Does leaf removal at 4 mm berries result in less botrytis bunch rot than vines with no leaf removal?*
3. For each test treatment, test a single aspect of one practice at a time; for example, you might change the timing of a fungicide spray (relative to current practice) without also changing the rate and method of application.

Q.3 Trial design

1. Select a suitable vineyard block for the trial site and describe key features influencing the crop attribute of interest and its spatial variability, e.g. disease hot spots.
2. Decide how many rows will receive the test treatment based on the equipment used to apply the treatment and/or the need for buffer rows. Allocate the same number of rows to 'current practice'.
3. Decide if additional trial strips are needed for 'current practice' to check for gradients in the crop's response across the trial area.
4. Decide what to measure in reference to the trial question/s and how the measurement will be conducted in the central row/s of each trial strip.
5. Review the layout of trial strips by listing potential row-by-row comparisons. Are vine rows allocated for measurements and comparisons close enough?
6. Position the trial strips in the vineyard block using the key principle for trial positioning stated above. Use spatial data (maps), if available, of relevant land or crop variables known to vary with the crop attribute of interest (yield, disease severity etc) e.g. Figure Q.3.
7. Select additional observations to aid in interpreting the trial results.
8. Prepare a trial plan that describes the trial purpose, question/s, site, layout, positioning and crop measurements.

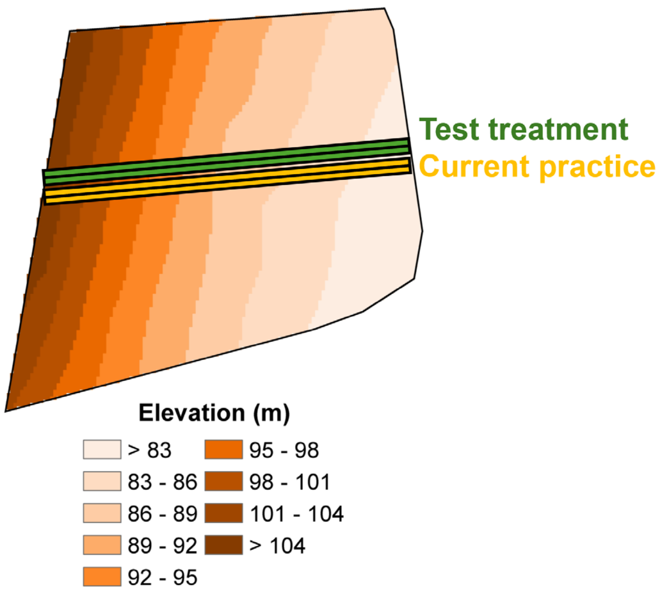


Figure Q.3 Hypothetical example of a crop protection trial in a vineyard block where three vine rows have been selected for each trial strip for comparison of the test treatment with current practice. Disease severity is known to vary with elevation based on observations from previous growing seasons.

Q.4 Implement trial and gather observations

1. Mark out the trial.
2. Apply test treatment/s.
3. Confirm who will be responsible for data collection, analysis and reporting, and their availability at the relevant time/s.
4. Record treatment date/s, crop stages and/or any issues, errors during implementation or extreme weather events.
    a. Abandon the trial if any factors have affected trial integrity
5. Determine the sampling frequency for crop measurements along a row to achieve a minimum of 25 sample vines (manual data collection only).
6. Record data on a recording sheet or via a suitable digital application. Transfer or import data to a spreadsheet.

Q.5 Analyse and report

1. Calculate single vine and row averages with the aid of a spreadsheet.
2. Select a suitable window size (e.g. n = 5) to calculate an ordered sequence of moving window averages using the individual vine averages or scores (see Figure Q.5.1).
3. Prepare graphs of moving window averages so that the lines for the test treatment and current practice can be compared directly on the same graph, e.g. Figure Q.5.2.
4. Describe the trial results
    a. Is there are a clear difference in the magnitude of the moving window averages between the test treatment and current practice? Is the difference large enough to be useful in practice?
        i. At most locations in the trial strip?
        ii. At some but not all locations in the trial strip?
        iii. At none of the locations in the trial strip?
    b. Are the shapes of the lines for the test treatment and current practice similar or different? Is the difference larger in some sections of the trial strip than others?

Optional

For those who need a statistical test, the difference in the average effect between the test treatment and current practice can be explored using an appropriate two-sample statistical test.

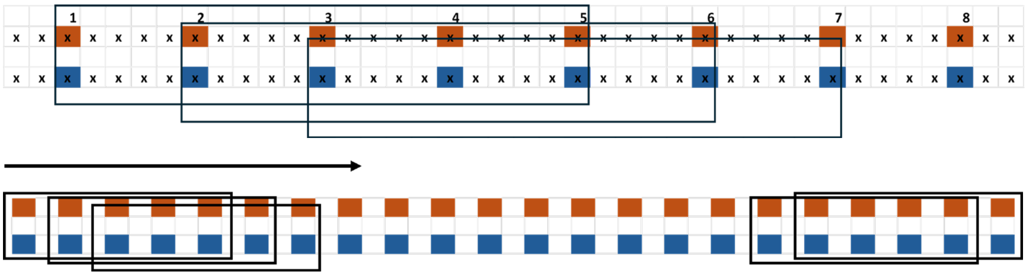


Figure Q.5.1 Illustration of moving window averages for a window size of five (n = 5). Every coloured square in the top panel represents a measurement of a sample vine for every fifth vine along the row (orange for current practice; blue for test treatment). The mean value for the first five sample vines is calculated (bottom panel) and then the window is shifted by one sample vine to calculate the mean value for the next five sample vines, and so on.

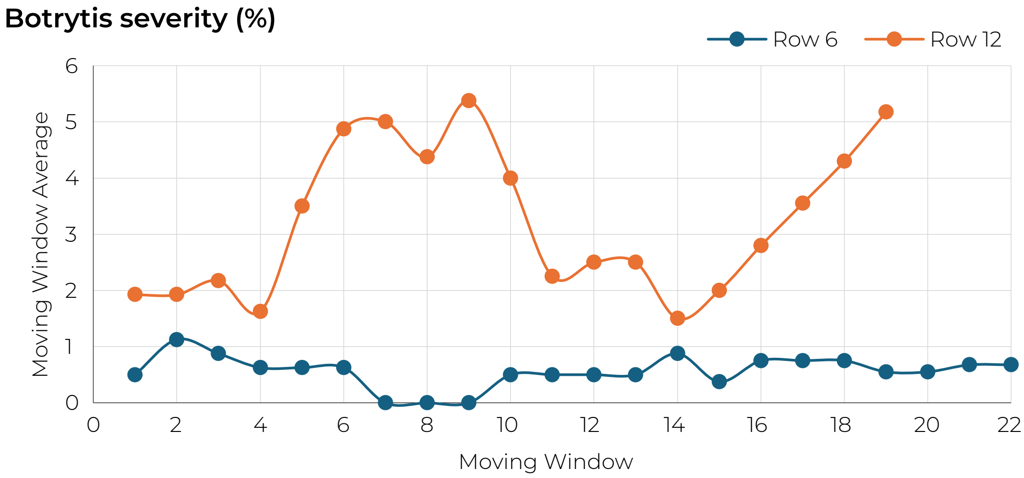


Figure Q.5.2 Moving window averages for a window size of five, for botrytis bunch rot severity in trial strips where row 6 is the current practice and row 12 is a test treatment where a fungicide product was omitted during the flowering period.

Q.6 Draw conclusions and plan next steps

1. Use the flow diagram in Figure Q.6 and involve relevant expertise, if necessary, to aid interpretation of trial results.
2. Communicate and discuss the results with those who have a vested interest in how the grapes are produced and/or processed.
3. Decide on a broad course of action and prepare a high-level action plan.
   a. Will you repeat the trial in a different growing season?
   b. Will you test something different?
   c. Do you have enough information to change your viticultural practice?
   d. Is it worth investing in change?
   e. What support will you need to make the change?
   f. What conversations do you need to have and with whom?

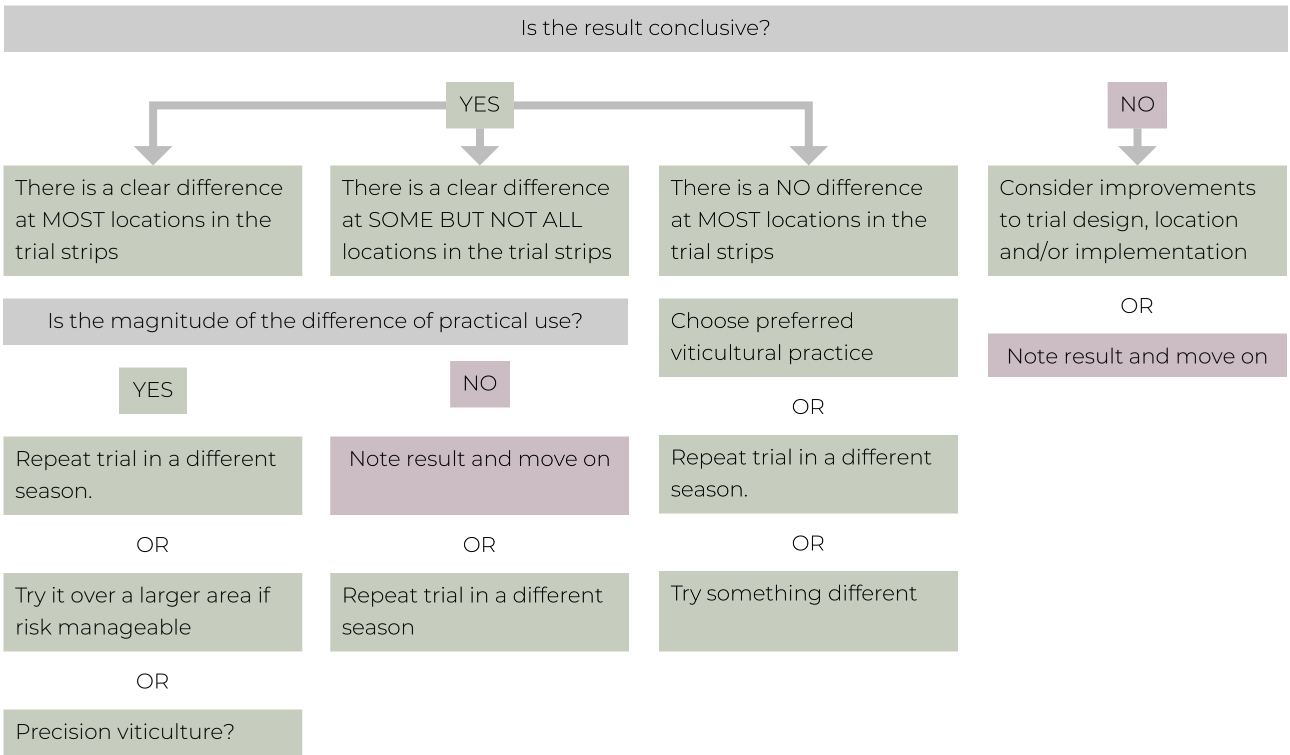


Figure Q.6 Interpretations of trial results and potential decisions flowing from them.

MODULE 1

How do I plan a trial successfully?

This first module describes the lifecycle of a trial, how to develop a suitable trial question, where to position the trial, and preparation of a trial plan that considers what actions will be taken, when and by whom.

Key points

- Prepare a trial plan and budget
- Set an appropriate trial question to prevent unnecessary data collection
- Test a single aspect of one practice at a time
- Position trial strips to cover maximum spatial variability in the crop's response
- Use multiple trial strips when spatial variability is across (not down) rows
- Review trial strip position if the same site is used for trials over years
- Update the trial plan as circumstances change

Key concepts

Crop response	Is the change in crop yield or other crop attribute after applying a particular management practice, e.g. a fungicide, compost or a canopy manipulation.
Current practice	Is the way the vines are cultivated and managed in the vineyard block and growing season in which the trial is being conducted. Current practice may change over time, with or without trials.
Test treatment	Is a new or modified practice that is being tested through the conduct of a trial.
Trial site	Is the area in a vineyard block allocated for the conduct of a trial.
Trial strip	Is one or more entire rows in a vineyard block where the vines are managed uniformly, either as 'current practice' or the 'test treatment'.
Vineyard block	Is an area of a single variety of grapevines within a vineyard that is managed uniformly.

Planning preliminaries

The outcome of planning for a trial is a written trial plan. Use Template 1.0 to guide the content of your trial plan as you work through the steps in this module. Timely updates to your trial plan as the trial progresses will prepare you well for success.

Remember the 5Ps: Proper Preparation Prevents Poor Performance.

Key stages of a trial

Knowing the six key stages in a trial can help identify what you need to plan for and who needs to be involved at any given stage in the process (Table 1.0). These stages will be covered in detail in the next sections.

Table 1.0 Key stages of a trial

Stage	Description	Questions to be answered
1	Trial purpose	What is the issue? What question do you want to answer?
2	Trial design	What is the layout and where? How will the crop be treated?
3	Gather observations	What observations and data do you need to collect? How?
4	Analyse and report	How will data be analysed and reported?
5	Draw conclusions	Who needs to be involved in interpreting the results?
6	What's next?	What decisions need to be made and by whom?

The trial cycle

A trial should be approached like any other on-vineyard operation. It starts with a plan and like any plan, plans can change!

Conceptually, trialling is an ongoing cycle of planning, doing, observing and reflecting on the outcome (Figure 1.0.1). Your trial plan may need to be reviewed and adapted several times during a growing season as conditions or operational needs change. Involving others in the process is also an opportunity to learn something new together and develop a common language around the trial method. Working together on a trial may even prompt new conversations that help solve other on-ground issues and/or serve to build strong working relationships. Stopping to reflect during the trial can lead to vast improvements in the process and the outcomes.

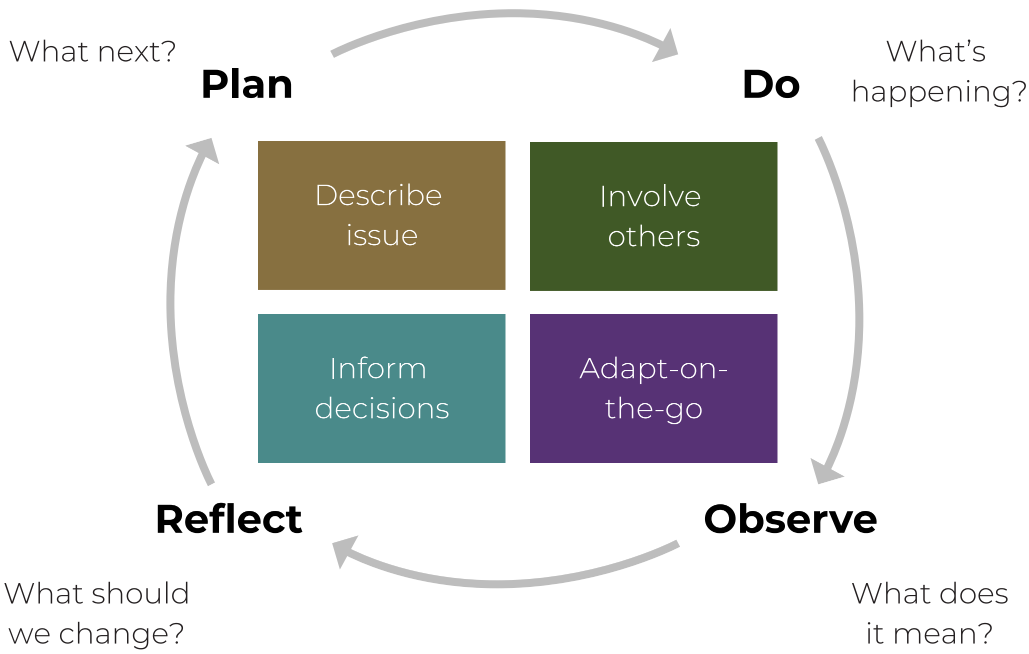


Figure 1.0.1 Conducting a trial is like any other vineyard operation in that it involves cycles of planning, doing, observing and reflecting on what is observed. Involving others may prompt new plans and conversations for adaptive management.

Data collection or not?

Manual data collection is arguably the most time-consuming task in conducting a trial. It also often occurs near harvest when people are stretched to maximum capacities. It can be tempting to “look-and-see” what happens without collecting data.

If a trial is done without collecting data, then there should be some prior evidence to believe that a treatment effect will be seen. For example, vines with a history of low nitrogen (N) status are likely to respond to treatment with N at the right time, with the effect observable with the naked eye (Figure 1.0.2). Nonetheless, minimal data collection and simple analyses can support evidence-based arguments for practice change. For example, measuring YAN (yeast available nitrogen) after nitrogen application along trial rows in which the soil type varies may reveal that the magnitude of the response varies with location in the row. In this regard, in-vineyard trials will be truly transformed when trial data can be collected cost-effectively by remote or on-the-go sensing. Photographs of large visible effects (e.g. Figure 1.0.2) are worth documenting as they help to tell the ‘data-driven’ story of the trial.[1]

Figure 1.0.2 A trial in vines with a history of low nitrogen (N) status. A difference in leaf colour can be seen for vines treated with N or not. Such a difference may not be seen in vineyards fertilised regularly with N.

Image supplied by Dr Tian Tian, University of California Cooperative Extension, Kern County, USA, and Dr Paul Schreiner, USDA Agriculture Research Service, Corvallis, Oregon, USA. Refer to Tian, T. (2024)[1].

Planning and prioritisation are key

The viticultural world is replete with examples where trial data and observations have been collected meticulously and then filed, never to see the light of day again. Consideration must be given to allocating and budgeting resources for data collation and analyses, and/or outsourcing the task, depending on in-house capacities.

Once completed, the trial plan should be reviewed in terms of the likely workload and available resources. Prioritise activities that are critical to success before deciding who and how tasks will get done. Consider those activities that could benefit from involvement of an expert or service provider. Trial planning may include locating appropriate expertise and, importantly, ascertaining their availability when needed. Refer to Module 3 for further discussion of the involvement of service providers.

1 Tian, T. (2024) Fertilization or supplement? How does nitrogen affect vine productivity and wine sensory quality in Chardonnay? In: *Wine Business Monthly.* Wine Business, pp. 52-53.

Template 1.0

Template 1.0 can be used to aid trial planning and guide the information to be included in a written trial plan.

Trial Planning Template

1. State the specific trial question

[*enter information here*]

2. What will be observed or measured? (What is the best indicator of the crop's response to the test treatment?) By whom?

[*enter information here*]

3. How many trial strips and where will they be positioned?

[*enter information here*]

4. Describe how the test treatment/s will be implemented.

[*enter information here*]

5. What general viticultural observations relevant to the trial will be made during the growing season? By whom?

[*enter information here*]

Trial Planning Template

6. Who will enter the trial data and crop observations to an Excel sheet (or equivalent)? Where will this data be stored? Who will process this data?

[*enter information here*]

7. Who will prepare the graph of trial results?

[*enter information here*]

8. Who needs to be involved in interpreting trial results?

[*enter information here*]

9. Who needs to be involved in deciding what happens next?

[*enter information here*]

1.1 Trial purpose

The purpose of each trial is to compare the producer's current practice with one or more test treatments that they want to try. This means that the control treatment is current practice.

A true control, such as not treating the crop with nutrients or fungicide, may be included if the producer understands and accepts the risk of potential crop loss or carryover effects into the next growing season.

Selecting the test treatment – some considerations

1. What are the risks, if any, of applying the test treatment? Are these acceptable risks?
2. Is extra labour needed to implement the test treatment? At what cost?
3. Will there be any adjustments to existing equipment? Is a test run needed?
4. Are there any unusual or complicated calculations for the test treatment? Who will review or check these?
5. Will the test treatment require any additional passes with equipment (e.g. the sprayer) to ensure all other (non-test) products are applied per current practice?

In the remainder of this section, we describe how to develop a suitable trial question so that the trial delivers information that is meaningful and easy to interpret.

Step 1.1.1 Describe the issue or opportunity

Use Template 1.1 to help you describe the general issue or opportunity that might be addressed by conducting a trial.

Once the general issue has been defined by you, then consider which variables or crop inputs are directly within your control and, if optimised, would help you reach your viticultural goals faster.

Consider using tools that help identify and rank key factors influencing viticultural outcomes at the production site of interest. The *Botrytis Checklist* (Resource 1.1), for example, helps identify the most important risk factors influencing the severity of botrytis bunch rot at any given production site. After completing the *Checklist*, consider the factors that are within your direct control, then choose the new or modified disease management tactic that you want to try.

Step 1.1.2 Set the trial question

Setting an appropriate trial question is crucial to producing meaningful results without unnecessary data collection. Once you have arrived at a trial question add it to Template 1.0 or your own trial plan.

In setting the question, start with the end in mind; that is, imagine the results (positive, negative, neutral) and the conclusions that might be drawn from the trial results. Think about the potential magnitude of the difference in the crop's response between a test treatment you have in mind and the current practice. What level of improvement is needed? Do you have some target number for yield or quality attribute, or are you trying to reduce the problem below some threshold level e.g. disease severity?

Table 1.1.2 contains examples of specific trial questions for which the answer can be 'yes' or 'no' if crop responses to treatment are similar at most locations in the trial area. In practice, the crop's response is likely to vary among locations in the vineyard block. We account for spatial variability through trial positioning and the way in which data are analysed and interpreted (see later sections). For now, setting the trial question is like the method used by researchers for hypothesis testing; however, we are not hypothesis testing nor relying on statistical analyses for interpretation of trial results.

Table 1.1.2 Examples of specific trial questions where the answer is 'yes' or 'no'; that is, the trial result is conclusive. The corresponding conclusions that might be drawn are listed against each trial question. Note, however, that the answer to the trial question can vary at different locations in the trial area as described in later sections.

Trial question	Answer	Potential conclusions
Does the substitution of fungicide *x* for fungicide *y* for the mid-flowering spray result in less botrytis bunch rot?	Yes	Disease severity at harvest **was lower** in vines receiving fungicide *x* than vines treated with fungicide *y*.
	No	Substitution of fungicide *x* for fungicide *y* had **no effect** on disease severity at harvest.
	No	Disease severity at harvest **was higher** in vines receiving fungicide *x* than vines treated with fungicide *y*.
Does leaf removal on one side of the canopy at crop stage *z* result in less botrytis bunch rot at harvest than vines with no leaf removal?	Yes	Disease severity at harvest **was lower** in vines in which leaves had been removed at crop stage *z* than vines with no leaf removal.
	No	Leaf removal at crop stage *z* had **no effect** on disease severity at harvest.
	No	Disease severity at harvest **was higher** in vines in which leaves had been removed at crop stage *z* than vines with no leaf removal.
Does the addition of compost in spring [specify date, year] result in higher pruning weights in the subsequent winter?	Yes	Winter pruning weights **were higher** in vines treated with compost in the preceding spring than vines not treated with compost.
	No	The addition of compost in spring had **no effect** on pruning weights in the subsequent winter.
	No	Winter pruning weights **were lower** in vines treated with compost in the preceding spring than vines not treated with compost.

The above examples illustrate that trial results are easier to interpret when the 'test treatment' involves change to only one aspect of a practice; for example, you might change the timing of a crop input without also changing the rate (dose) and method of application. If the test treatment involves a change in all three factors at once (product, rate, application method) then it will not be known which factor/s contributed to the observed treatment effect. Selecting a test treatment that explores a single aspect of a practice can at least help identify key factors driving any difference between the test treatment and current practice.

How many test treatments per trial?

A trial can be designed to explore changes in more than one aspect of a practice without confounding the interpretation of the results. For example, refer to section 1.2.2 for examples of trial layouts with two test treatments. Trial size and complexity will increase significantly with more than two test treatments. Ultimately, the number of test treatments will be limited by the number and length of vine rows, available resources to implement and assess the trial, and the perceived risk of applying an unknown test treatment over a large area of vines.

Template 1.1

Template 1.1 provides a series of questions to help you identify a potential trial topic.

1. What is the key issue?

[*enter text here*]

2. Why is this a key issue? (Why is this important?)

[*enter text here*]

3. What do you already know about the issue?

[*enter text here*]

4. What else do you want to know?

[*enter text here*]

5. What are the key factors or crop management variables that could be investigated by conducting a trial?

[*enter text here*]

Resource 1.1

#	Title	Description
1.1	*Botrytis Checklist* available from http://bit.ly/42POBdj under the Resources tab	A checklist to help identify and rank key factors influencing the severity of botrytis bunch rot at a production site of interest. Developed with and for producers of wine grapes in Tasmania.

1.2 Trial design

In this section we describe the selection and description of the vineyard block in which the trial will be located, how to layout the trial strips and decisions on what to measure.

Step 1.2.1 Select and describe trial site and layout

Select a suitable vineyard block for the trial site based on the presence of the issue and the potential to address the issue through changes to one or more viticultural practices.

Use Template 1.2.1 to guide your description of the vineyard block in which the trial will be situated. The trial rows or strips can be labelled once you have determined the positioning of the trial (Step 1.2.2). Note any features of the vineyard block or surrounds that might influence vine microclimate, airflow or humidity, including large bodies of water, tall trees casting shade across vines, or shelter belts.

The area of the trial within the selected vineyard block and, more importantly, its layout, must fit well with existing operations. In general, this means applying the test treatment with commercial equipment to the entire length of one or more vine rows. 'Current practice' is the remainder of the vineyard block; however, it is necessary to mark out an equivalent and virtual trial strip for 'current practice' that is adjacent to the trial strip for the test treatment (Figure 1.2.1). Flagging tape is usually used to mark the end of each vine row that will receive the test treatment. The virtual trial strips for 'current practice' can also be identified using flagging tape; however, this is unnecessary if the trial layout is described clearly in the written trial plan.

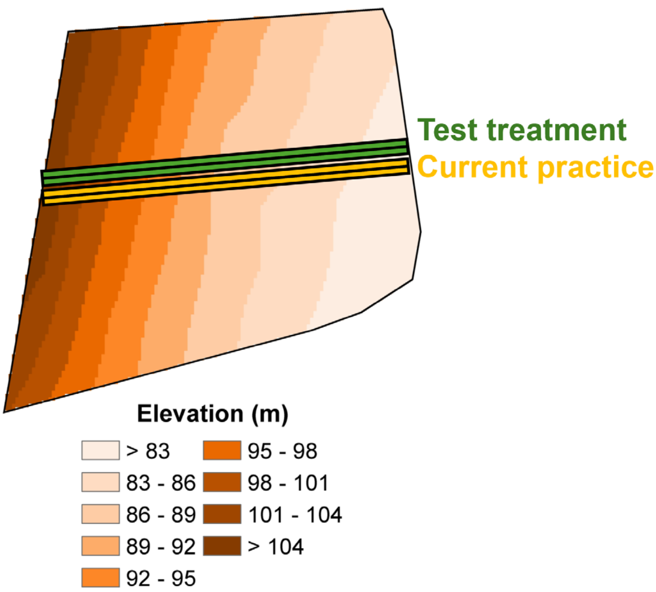


Figure 1.2.1 Schematic representation of three vine rows selected to receive a test treatment for comparison with current practice in an adjacent three-row trial strip. In this vineyard block, elevation varies along each vine row. Image of elevation derived from Bramley *et al.* (2011)[2].

[2] Bramley, R. G. V., Evans, K. J., Dunne, K. J. and Gobbett, D. L. (2011) Spatial variation in response to 'reduced input' spray programs for powdery mildew and botrytis identified through whole-of-block experimentation. *Australian Journal of Grape and Wine Research*, **17,** 341-350.

How many vine rows per trial strip?

The minimum trial strip is a single row of vines. Multiple vine rows per trial strip may be needed for logistical reasons such as the number of rows covered by a sprayer in a single pass or to account for normal patterns of tractor passes for other operations. Buffer rows may also be needed to prevent a test spray drifting to adjacent areas or for canopy manipulations (e.g. leaf removal or shoot thinning) likely to alter canopy microclimate and/or light interception.

The next three examples illustrate how to use the trial question to develop a trial layout. The first example is the simplest trial layout with one test treatment. The next two examples illustrate trial layouts for two test treatments.

Trial layout 1

Let's consider the trial layout for the following question:

Does leaf removal (leaf plucking) prior to the application of fungicides at crop stage E-L 29[3] *(4 mm berries) result in less botrytis bunch rot at harvest than vines with no leaf removal?*

The treatments are:

Current practice: No leaf removal prior to fungicides applied at 4 mm berries.

Test treatment 1: Leaf removal prior to fungicides applied at 4 mm berries.

See Table 1.2.1.1 for a potential trial layout, while noting that the actual row numbers will be determined by applying the principles of trial positioning (see Step 1.2.2). The first assessment row is row 3, thus avoiding any potential edge effects of the two rows situated at one end of the vineyard block.

Given the test treatment is leaf removal, then one buffer row either side of the row to be used for disease assessment should be sufficient to reduce any impact of the test treatment on the row used for assessment of current practice, and *vice versa*.

Table 1.2.1.1 Schematic representation of row selection for one test treatment involving leaf removal. It is assumed that disease severity will be assessed using the centre row of each 3-row trial strip, i.e., row 3 (current practice) and row 6 (test treatment).

Vine row number	Treatment	Leaf removal	Measurements
1	Current practice	No	
2	Current practice	No	
3	Current practice	No	**Assess this row**
4	Current practice	No	
5	Test 1	Yes	
6	Test 1	Yes	**Assess this row**
7	Test 1	Yes	
8 onwards	Current practice	No	

Trial layout 2

[3] Coombe, B. G. (1995) Adoption of a system for identifying grapevine growth stages. *Australian Journal of Grape and Wine Research*, **1,** 104-110.

Let's now consider the layout for a more complex trial with the following two questions:

1. *Does substitution of fungicide x for fungicide y at crop stage E-L 29 (4 mm berries) result in less botrytis bunch rot?*
2. *Does leaf removal prior to the application of fungicide x (only) at crop stage E-L 29 (4 mm berries) result in less botrytis bunch rot at harvest than vines with no leaf removal?*

The treatments are:

Current practice: No leaf removal, fungicide *x* applied at 4 mm berries

Test treatment 1: No leaf removal, fungicide *y* applied at 4 mm berries

Test treatment 2: Leaf removal, fungicide *x* prior to fungicide application at 4 mm berries

See Table 1.2.1.2 for a potential trial layout, while noting that the actual row numbers will be determined by applying the principles of trial positioning (see Step 1.2.2). Five rows are used for each test treatment because buffer rows are needed to capture any spray drift.

Table 1.2.1.2 Schematic representation of row selection for two test treatments that involve applications of spray materials. Five rows are allocated to each treatment to provide buffer rows for potential spray drift. It is assumed that disease severity will be assessed using the centre row of each 5-row trial strip, i.e., rows 3, 8, 13 and 18.

Vine row number	Treatment	Fungicide	Leaf removal	Measurements
1	Current practice	Fungicide *x*	No	
2	Current practice	Fungicide *x*	No	
3	Current practice	Fungicide *x*	No	**Assess this row**
4	Current practice	Fungicide *x*	No	
5	Current practice	Fungicide *x*	No	
6	Test 1	Fungicide *y*	No	
7	Test 1	Fungicide *y*	No	
8	Test 1	Fungicide *y*	No	**Assess this row**
9	Test 1	Fungicide *y*	No	
10	Test 1	Fungicide *y*	No	
11	Test 2	Fungicide *x*	Yes	
12	Test 2	Fungicide *x*	Yes	
13	Test 2	Fungicide *x*	Yes	**Assess this row**
14	Test 2	Fungicide *x*	Yes	
15	Test 2	Fungicide *x*	Yes	
16	Current practice	Fungicide x	No	
17	Current practice	Fungicide x	No	
18	Current practice	Fungicide x	No	**Assess this row**
19	Current practice	Fungicide x	No	
20	Current practice	Fungicide x	No	
21 onwards	Current practice	Fungicide *x*	No	

Looking at the trial layout (Table 1.2.1.2), the addition of a second trial strip for current practice (rows 16–20) can help identify if disease severity in row 18 is similar in magnitude to that observed in row 3. If not, then there may be a potential gradient in disease severity across the block. Spatial variability in disease severity can be accounted for (to some degree) by careful selection of assessment rows for row-by-row comparisons (Table 1.2.1.3). Otherwise, there may be benefit in understanding, and indeed mapping, the spatial variability of the crop attribute being measured before conducting a trial. Refer to Module 4 for a relevant case study.

Table 1.2.1.3 Potential row-by-row comparisons once data are collected and analysed. These comparisons are selected because they directly address the trial questions. Comparison of rows 3 and 18 - both current practice – can indicate spatial variability in disease severity.

#	Description	Rows being compared
1	Current practice vs Test 1	3 vs 8
2	Test 1 vs Test 2	8 vs 13
3	Current practice vs Test 2	18 vs 13
4	Current practice vs Current practice	3 vs 18

Trial layout 3

This example of a trial layout is an extension of Trial layout 2, in that all variables (fungicide *x* or *y*; leaf removal or not) are compared in all possible combinations.

The trial questions are:

1. *Does substitution of fungicide x for fungicide y at crop stage E-L 29 (4 mm berries) result in less botrytis bunch rot?*
2. *Does leaf removal prior to the application of fungicide x at crop stage E-L 29 (4 mm berries) result in less botrytis bunch rot at harvest than vines with no leaf removal?*
3. *Does leaf removal prior to the application of fungicide y at crop stage E-L 29 (4 mm berries) result in less botrytis bunch rot at harvest than vines with no leaf removal?*

The treatments are:

Current practice: No leaf removal, fungicide *x* applied at 4 mm berries

Test 1: No leaf removal, fungicide *y* applied at 4 mm berries

Test 2: Leaf removal, fungicide *x* applied at 4 mm berries

Test 3: Leaf removal, fungicide *y* applied at 4 mm berries

Refer to Tables 1.2.2.4. and 1.2.2.5 for the potential trial layout and row-by-row comparisons.

Table 1.2.1.4 Schematic representation of row selection for three test treatments that involve all variables (fungicide *x* or *y*; leaf removal or not) in all possible combinations. Five rows are allocated to each treatment to provide buffer rows for potential spray drift. It is assumed that the crop response (e.g. disease severity) will be assessed using the centre row of each 5-row strip.

Vine row number	Treatment	Fungicide	Leaf removal	Measurements
1	Current practice	Fungicide *x*	No	
2	Current practice	Fungicide *x*	No	
3	Current practice	Fungicide *x*	No	**Assess this row**
4	Current practice	Fungicide *x*	No	
5	Current practice	Fungicide *x*	No	
6	Test 1	Fungicide *y*	No	
7	Test 1	Fungicide *y*	No	
8	Test 1	Fungicide *y*	No	**Assess this row**
9	Test 1	Fungicide *y*	No	
10	Test 1	Fungicide *y*	No	
11	Test 2	Fungicide *x*	Yes	
12	Test 2	Fungicide *x*	Yes	
13	Test 2	Fungicide *x*	Yes	**Assess this row**
14	Test 2	Fungicide *x*	Yes	
15	Test 2	Fungicide *x*	Yes	
16	Test 3	Fungicide *y*	Yes	
17	Test 3	Fungicide *y*	Yes	
18	Test 3	Fungicide *y*	Yes	**Assess this row**
19	Test 3	Fungicide *y*	Yes	
20	Test 3	Fungicide *y*	Yes	
21	Current practice	Fungicide x	No	
22	Current practice	Fungicide x	No	
23	Current practice	Fungicide x	No	**Assess this row**
24	Current practice	Fungicide x	No	
25	Current practice	Fungicide x	No	
26 onwards	Current practice	Fungicide *x*	No	

Table 1.2.1.5 Potential row-by-row comparisons once data are collected and analysed. Comparison of rows 3 and 23 - both current practice – can reveal spatial variability in disease severity.

#	Description	Rows being compared	Constant
1	Current practice vs Test 1	3 vs 8	No leaf removal
2	Test 1 vs Test 2	8 vs 13	-
3	Current practice vs Test 2	3 vs 13 or 23 vs 13	Fungicide *x*
4	Test 2 vs Test 3	13 vs 18	Leaf removal
5	Test 1 vs Test 3	8 vs 18	Fungicide *y*
6	Current practice vs Test 3	23 vs 18	-
7	Current practice vs Current practice	3 vs 23	Current practice

Note how the size and complexity of the trial increases with each additional test treatment.

Step 1.2.2 Position trial strips

Once a trial layout is determined, then the next step is to position the trial strips by selecting appropriate rows in the vineyard block.

Key principle of trial positioning

Vineyard rows selected for trial strips are those likely to capture the maximum range of the crop's response to treatment. This means that when the crop is measured, both high, low and near-average values of the crop measure (e.g. yield, disease severity) are observed in the trial strip. The trial strip is positioned to encompass rather than minimise spatial variability in the crop's response.

The reason for encompassing spatial variability in a trial strip will become clearer once the method for displaying and interpreting trial results is presented (Sections 2.3 and 2.4). For now, look back at Figure 1.2.1 which illustrates that the trial strips traverse nearly every elevation observed in the block. Such positioning is appropriate if the crop attribute of interest (e.g. disease severity) is known to vary with elevation. In this scenario, the trial results should provide insights on how the test treatment performs across the range of disease severities likely to be expressed in the vineyard block of interest.

Information from previous growing seasons about spatial patterns of yield, disease severity or any other variable of interest can be used to position trial strips. If there is no access to spatial data, or 'maps', then an experienced producer can position trial strips based on their previous observations of crop variability. The benefit of positioning trial strips in this way is that information on the variability of the crop's response to treatment along a row can be related to other locations in the vineyard block with features that are like those observed within the trial strip. There is a scientific method[4] to optimise the positioning trial strips; however, application of the method requires a high degree of technical skill and access to spatial data.

The next five scenarios illustrate the principles and practice of positioning trial strips.

[4] Song, X., Bramley, R. G. V. and Evans, K. J. (2023) A method to position a simple strip trial to improve trial efficiency and maximise the value of vineyard variability for decision-making. *OENO One*, **57,** 97-107.

Positioning scenario 1

Figure 1.2.2.1 illustrates spatial variability in botrytis bunch rot (BBR) and elevation in plantings of Sauvignon Blanc at a site in northern Tasmania in 2019. The maps suggest a trend for more severe BBR at lower elevations. The two blocks at lower elevation appear to cover the range in BBR severities observed (panel (b) of Figure 1.2.2.1). Given the NE to SW row orientation, then trial strips could be positioned anywhere in either of these two lower blocks if the strips cover all mapped categories of BBR severity. The trial could also be conducted in a block at higher elevation to capture crop responses where BBR severity is relatively low. In practice, it is unlikely that vineyards will have historical maps of BBR severity. Nonetheless, a producer who is familiar with the site and knows the principle of trial positioning is likely to position trial strips in an optimal way.

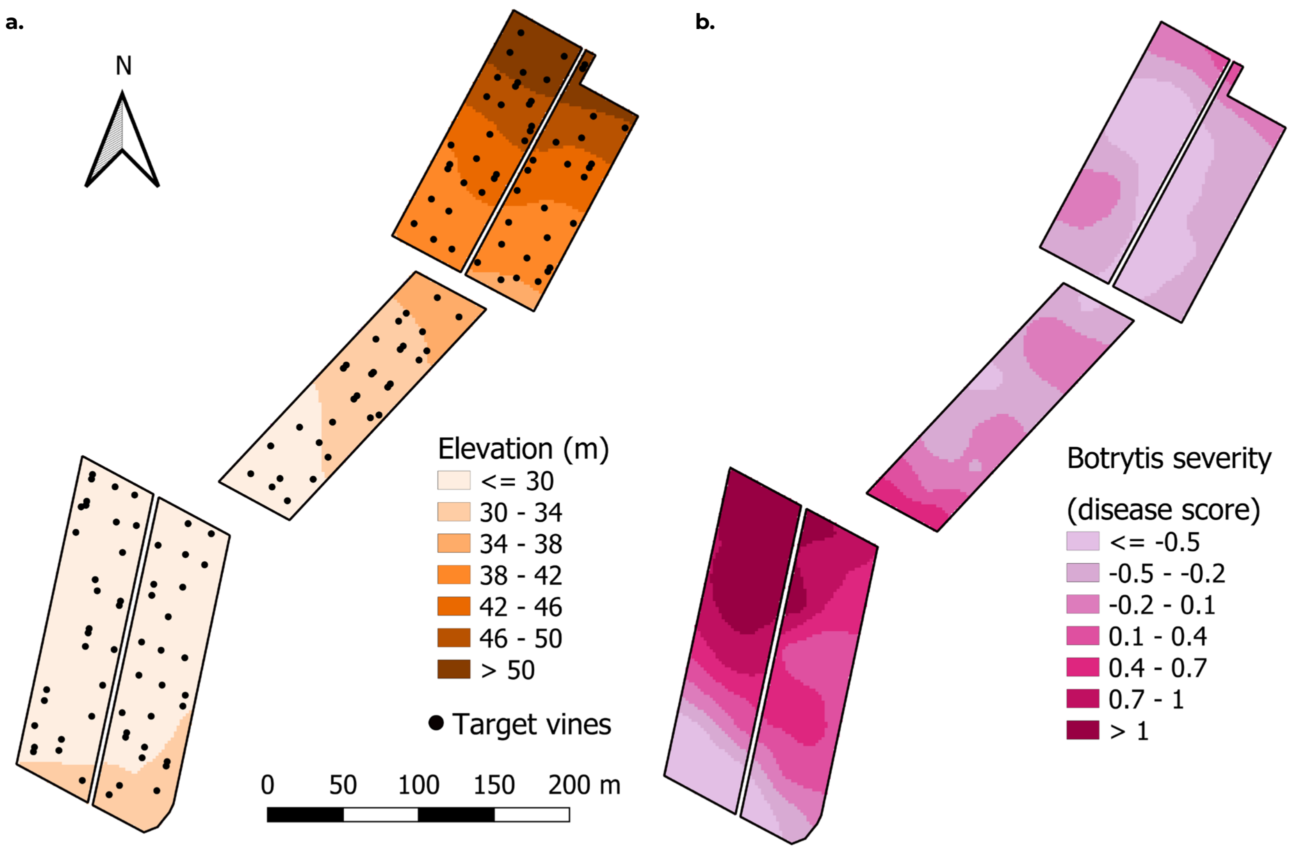


Figure 1.2.2.1 Reproduced from Evans and Pirie (2024)[5] and Song (2022)[6], a) elevation (minimum: 26.6 m, maximum: 53.9 m above sea level) and (b) BBR severity (%) on 27 March 2019, 19 days before commercial grape harvest. The five vineyard blocks represent a total of 4.8 ha of Sauvignon Blanc vines near Kayena, Tasmania with mean BBR severities (%) in ascending order): 0.6, 1.7, 2.9, 5.4 and 10.1 (SE for each mean: 0.002-0.018, n = 25-30).

[5] Evans, K. J. and Pirie, A. J. G. (2024) Weather variables for within-vineyard awareness of botrytis risk. *Australian Journal of Grape and Wine Research*, 17 pages. https://doi.org/10.1155/2024/6630039

[6] Song, X. (2022) On-farm experimentation in the Australian winegrape sector: approaches and opportunities for change. PhD Thesis. Hobart, Tasmania: University of Tasmania, pp. 210.

Positioning scenario 2

The map in Figure 1.2.2.2 illustrates another example of spatial variation in botrytis bunch rot (BBR) severity for a 2.4 ha block of Chardonnay in southern Tasmania. Hypothetical trial strips, A, B or C, illustrate that strip A likely captures the broadest range of potential BBR severities observed in the block. If the trial was positioned according to strip B or C, then the differences in the crop's response between current practice and the test treatment would remain unknown for higher disease severities observed elsewhere in the block. Like the previous scenario, access to a map of BBR severity is unlikely; however, tools for on-the-go sensing of disease severity are likely to be developed in time.

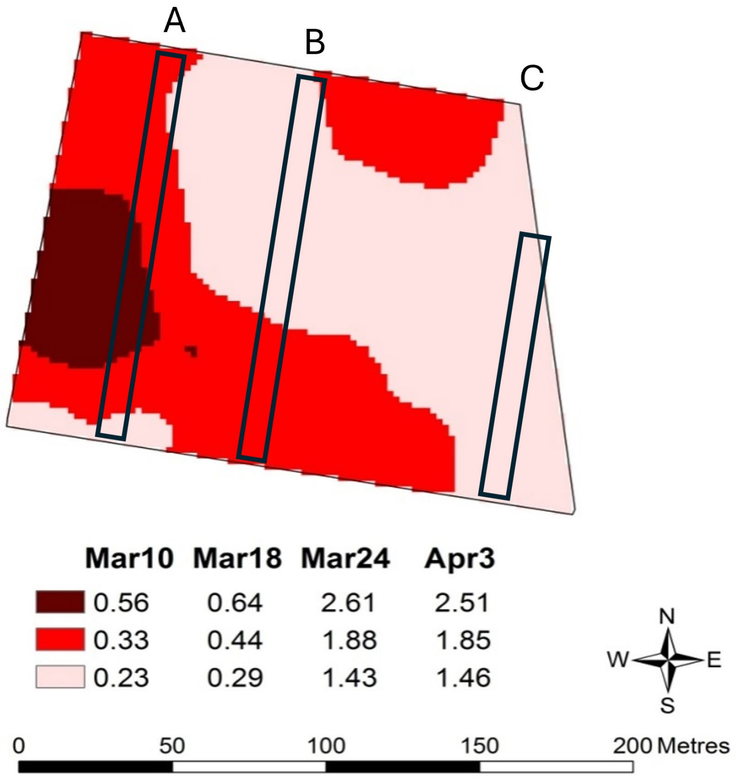


Figure 1.2.2.2 Spatial variation in botrytis bunch rot severity in a 2.4 ha block of Chardonnay vines in 2009 (Bramley et al., 2011)[7]. The numbers beneath the map represent average botrytis severity in each of the different coloured zones, and how these changed in the days preceding harvest in April.

[7] Bramley, R. G. V., Evans, K. J., Dunne, K. J. and Gobbett, D. L. (2011) Spatial variation in response to 'reduced input' spray programs for powdery mildew and botrytis identified through whole-of-block experimentation. *Australian Journal of Grape and Wine Research,* **17,** 341–350.

Positioning scenario 3

This scenario is about the situation when the gradient of the crop's response to treatment is across vine rows rather than along the rows (scenarios 1 and 2). The map in Figure 1.2.2.3 illustrates that the issue being addressed – powdery mildew severity - was more severe at higher elevation. However, the vine rows are aligned to the topographical contours. This means that any rows selected for a strip trial are unlikely to encompass the full range of powdery mildew severities observed in the block. In this scenario, it may be necessary to position multiple trial strips to capture the full range of potential crop responses.

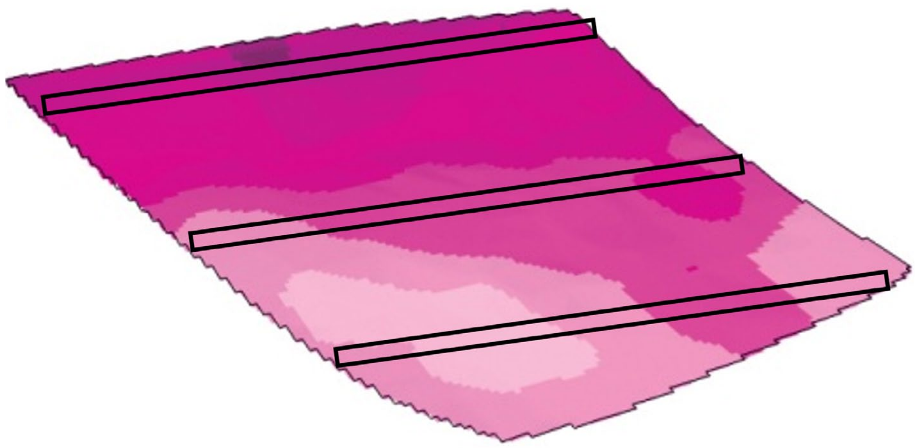


Figure 1.2.2.3 A hypothetical example where a trial strip (black rectangle) is repeated at multiple locations in a block because the disease gradient is perpendicular to the row orientation. Image derived from Bramley *et al.* (2011)[8].

[8] Bramley, R. G. V., Evans, K. J., Dunne, K. J. and Gobbett, D. L. (2011) Spatial variation in response to 'reduced input' spray programs for powdery mildew and botrytis identified through whole-of-block experimentation. *Australian Journal of Grape and Wine Research,* **17,** 341–350.

Positioning scenario 4

This scenario deals with the challenge of variable row lengths in the block, especially short rows that may not provide sufficient sample vines for graphical presentation of results (see Section 2.3). One way to increase the length of a row, especially for sites or areas of the block where all rows are relatively short, is to do so by creating virtual rows; that is, trial strips can be repeated adjacent to or in another area of the block. These rows are then used to create one long virtual row by positioning each individual row end-to-end (in series) for the graphical presentation of results.

A related challenge with variable row lengths is when the block boundary at one or both ends of the vine rows is angled or curved so that vine number 3 in a row assigned for data collection, for example, is not in line (in a line drawn at right angles to the row) with vine number 3 in another row being used for the same purpose. Figure 1.2.2.4 illustrates a scenario where a trial was positioned between rows 22 and 46 in a total area of 1.2 ha of vines. While the positioning of trial strips in sufficiently long rows was appropriate, care was needed when viewing and interpreting trial results (see Sections 2.3 and 2.4). That is, comparisons of trial results between corresponding vine numbers in each assessment row are not necessarily direct comparisons unless the vine numbering is re-aligned to compare 'like with like' across sampled rows.

Figure 1.2.2.4 A 1.2 ha block of vines in which trial strips were positioned between rows 22 and 46. The block boundary at both ends of the vine rows was either angled or curved. While trial positioning was sound, the relevance of direct comparison of vine numbers in rows sampled for crop assessment needs to be taken into consideration when interpreting trial results.

Positioning scenario 5

This scenario deals with the situation where a trial is to be repeated or modified at the same trial site over time. In this scenario, it is important to consider whether the trial results in one or more trial strips could influence or confound the results observed in trial strips overlaid in a subsequent season.

Crop protection trials are particularly prone to carryover effects. For example, if the average disease severity in the row of a test treatment was significantly lower than for current practice, then those same rows may have a lower winter carryover of pathogen inoculum than other rows. Depending on the biology of the target pathogen, then rows in this trial strip might develop less disease than other rows in a subsequent trial.

For a repeat trial, then the test treatment could continue to be applied to the same rows, or it could be moved to rows managed using current practice in the previous season. The decision on row allocations for the test treatment will depend on the trial objective. For example, one objective may be to test a treatment under conditions that are highly favourable for disease development. Therefore, the test treatment might be moved to rows previously designated as 'current practice' because of the relatively high disease severities observed. Another objective might be to continue the same test treatment in the same rows to see if it reduces disease levels over time relative to current practice.

In short, it is important to remember that actions taken in a current season can impact the crop's response next season.

Step 1.2.3 Decide what to measure

Once committed to data collection, the trial question will guide the type of crop measurement needed.

Crop measurement

Ultimately, the decision on what to measure is guided by both the trial question/s and available resources to get the job done. A key consideration is the availability of someone who is trained to do this job. Is it a job for you or someone else like a vineyard worker or a service provider? Will you incorporate this task into your operational plan and budget, or will the several hours it might take become a routine activity that fits in with everything else on any given day?

If the trial is about botrytis bunch rot or powdery mildew, then options include assessing the percentage area of the grape bunch with disease symptoms (severity) and/or the proportion of grape bunches with disease symptoms (incidence). Refer to Resource 1.2 for information on how to assess botrytis bunch rot and powdery mildew in strip trials. Consult a relevant technical specialist if help is needed on selecting a crop measure and/or the assessment method for other crop attributes such as components of grape yield or vine vigour.

Check that the selected crop measure will answer the trial question. Consider also the potential to involve research scientists who may be able to take additional measurements for deeper insights. If so, all parties need to be mindful that the primary function of the trial is to achieve a practical and business-directed outcome. Refer to Module 3 for further discussion on the roles and responsibilities of trial collaborators.

The weather and other observations

In addition to crop measurement, other observations can aid interpretation of trial results in the context of seasonal and/or operational conditions.

Disease and pest risk, for example, can vary markedly among seasons. Weather records can be used to calculate proxy indicators of relative disease or pest risk. Each season in which a trial is conducted can then be described using a relevant weather-based descriptor. Such descriptors are likely to aid interpretation of results as discussed in Module 2. If disease or pest-specific weather variables are unavailable or inaccessible, then a producer may be able to draw on previous experience and records of those seasons when widespread crop losses due to a pest or disease were evident in their grape-growing region.

The source of the weather data matters if observational data are not obtained from a suitably located A-grade station such as those operated by the Australian Bureau of Meteorology. Check that the data are being recorded at desired time intervals; for example, 15 min intervals for calculation of hourly averages. It is also important to use the same source of data for all trials in case readings from one manufacturer's sensors are routinely high or low relative to those from a different supplier.

If specific weather data are needed for the trial, then check the status of weather station maintenance and/or data subscriptions. Rain gauges, for example, produce unreliable readings when debris are caught in the tipping bucket. If the weather station is serviced, then ask the service provider if they know the last time the sensors or probes were calibrated.

When recording weather data, note the height of the sensors above ground and note any vegetation in the vicinity (e.g. long grass) or tall trees or buildings that might be influencing sensor readings.

Refer to Template 1.2.2 for suggestions on observations to record during the trial. Relevant viticultural information might include dates for key crop stages, general crop inputs, and observations about extreme weather conditions and/or errors in trial implementation. Determine which observations will be recorded routinely during normal viticultural operations and those that need to be added to the work plan. For non-routine observations, write a note-to-self on the office whiteboard or in your diary so that it gets seen and is done!

Step 1.2.4 Prepare and update the trial plan

After working through the previous planning steps, update your entries to Template 1.0 for a ready reference to the purpose of the trial, the trial question/s, trial site, layout, positioning and crop measurements. Your written trial plan can be developed from there and updated again after working through the steps in Module 2.

Template 1.2.1

Use this template to describe the vineyard block and trial site.

Vineyard name: [*enter the vineyard name*]

Vineyard block/s: [*enter the name of the vineyard block or multiple blocks if the trial is being repeated in different blocks*]

Google map of vineyard block: *[add a Google map of the block like the one below; label trial rows once known]*

Variety and clone/s: [*enter the name of the grape variety and clone/s, if known*]

Trellis and training system: [*enter trellis type and training system*]

Vine spacing: [*enter the distance (m) between vines and between rows*]

Describe the issue last season: [*describe the issue as it appeared last season e.g. botrytis severity reached unacceptable levels in downslope areas of the block*]

Describe any other features of the block relevant to trial outcomes: [*describe relevant features, e.g. Lyre trellis system exacerbates spray coverage issues; tall trees of windbreak on western border cast shadows and reduce canopy exposure to UV light*]

Template 1.2.2

Template 1.2.2 provides a series of mini templates to capture crop inputs and conditions associated with the trial which in turn may aid interpretation of trial results.

Key crop growth stages

Name of trial block: [*enter information here*]

Variety and clone/s: [*enter information here*]

E-L stage	Description	Date (estimated or actual)
19	Start of flowering and less than 10% caps off	[*enter date*]
25	80% caps off	[*enter date*]
29	Berries 4 mm	[*enter date*]
31	Pre-bunch closure; berries pea-sized (7 mm)	[*enter date*]
34	Véraison: berries begin to soften and change colour	[*enter date*]
	Harvest date	[*enter date*]

Spray program

Spray records, if sufficiently detailed, can be attached to the trial results. Otherwise, use a table like the one below and add more rows as needed.

Include sufficient detail relevant to the purpose of the trial.

Attempt to specify actual E-L crop stages rather than listing the desired crop stage (they may be the same, but sometimes spray operations are delayed).

Add notes or observations about crop conditions, extreme weather, pest outbreaks, or equipment failures.

Date	E-L crop stage	All products in tank mix	Active ingredients	Amount of product (g or ml) per 100 L
[enter info]	*[enter info]*	*[enter info]*	*[enter info]*	*[enter info]*

Treatments applied

Note the details of each test treatment applied: when, where and how. Note any delays in application or equipment failures.

Add more rows as needed.

Date	E-L Crop stage	Treatment	Rows	Notes or Observations
Example: Jan 19, 2024	*33*	*Leaf plucking 30% - Pellenc machine* *East side*	*12,13,14,15*	*Planned for El 31 – operational constraints delayed implementation.* *A fresh tank mix of fungicide was prepared for rows 14-15 (after running out after row 13)*
[enter info]	*[enter info]*	*[enter info]*	*[enter info]*	*[enter info]*

Other observations

Add notes or observations about crop conditions, extreme weather, pest outbreaks, or equipment failures. Specific weather variables may also be included as indicators of the relative risk of severe crop injury caused by a specific pest or disease.

Add more rows as needed.

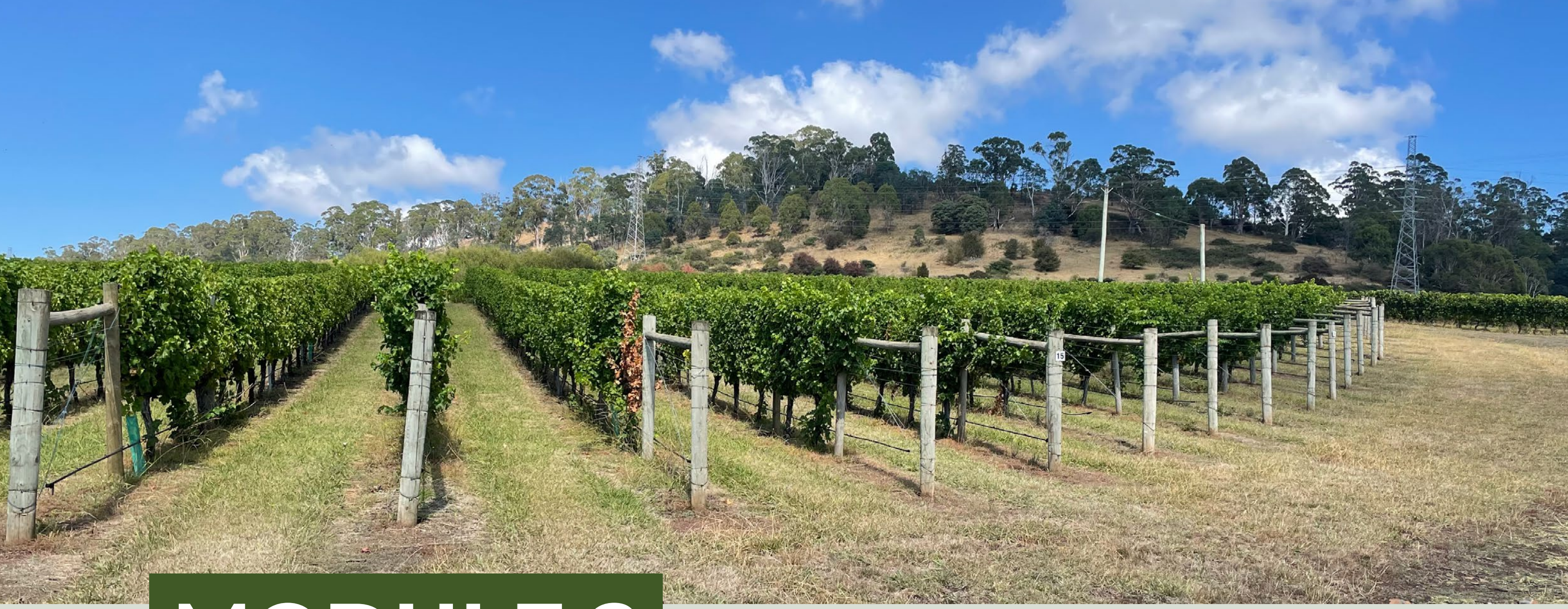
Date	E-L crop stage or range	Notes or observations
Example: Mar 2, 2024	*2 weeks before harvest*	*65 mm rainfall to 9 am*
Feb 15, 2024 to April 5, 2024	*Veraison to harvest date*	*The median value of the daily vapour pressure deficit of air at 3 pm was 1.002 kPa indicating that conditions were highly favourable for the development of botrytis bunch rot.*
[enter info]	*[enter info]*	*[enter info]*

Resource 1.2

#	Title	Description
1.2.1	*Disease Assessment Method* available from http://bit.ly/42POBdj under the Resources tab	A set of slides with notes on how to assess botrytis bunch rot and powdery mildew in trial strips of wine grapes.
1.2.2	*Assessing Botrytis Bunch Rot* available from https://www.youtube.com/watch?v=cW0vRWY4XGI	An instructional video to demonstrate in-vineyard sampling and disease assessment
1.2.3	*Botrytis Diagram* available from http://bit.ly/42POBdj under the Resources tab	A standard area diagram to aid assessment of botrytis bunch rot severity in wine grapes.
1.2.4	*Powdery Mildew Diagram* available from http://bit.ly/42POBdj under the Resources tab	A standard area diagram to aid assessment of powdery mildew severity in wine grapes.
1.2.5	*Recording Sheet Template* available from http://bit.ly/42POBdj under the Resources tab	A sheet to aid in-vineyard recording of disease severities in trial strips.

Resources

Instructional video



MODULE 2

How do I implement a trial successfully?

This module covers the essentials of implementing a trial according to the trial plan and/or adaption of the plan as circumstances change. We describe how to mark out the trial, implement crop treatments, gather data and observations, compile and interpret trial results, draw conclusions and plan next steps.

Continually review and adapt the trial plan in line with other operational changes and priorities that impact the conduct of the trial, and the people and other resources needed to get the job done.

Key points

- Adapt and update plans as needed
- Check availability of people for specific trial activities and/or advice
- Keep records of completed trial actions: date, details, issues, measurements
- Do simple calculations and graph results using an Excel spreadsheet
- Note and interpret spatial variability in the crop's response to treatment
- Decide whether results are conclusive and seek help, if needed, to interpret trial results
- Involve others in drawing conclusions and deciding next steps

2.1 Mark out trial and apply treatments

Step 2.1.1. Mark out the trial

1. Use weather-resistant flagging tape to mark the posts at the ends of rows allocated for the test treatment (mark both ends of row). Useful colours for flagging tape include fluoro pink, orange or white. Make sure the tape is highly visible for those operating equipment such as sprayers.
2. After the test treatment has been applied – in a single or multi-step operation - then consider also applying flagging tape to the rows allocated to crop measurement. This will then help the person assessing the trial to locate assessment rows and the vines to be sampled.
3. Check that the flagging tape and any signage (see below) remains in place for the duration of the trial. Replace any flagging tape if the colour has faded and remove the tape at the end of the trial.

Optional: trial signage can be developed and attached to a post or fence if you would like to promote your trial and/or those businesses providing trial-related crop inputs or services.

Optional: some people like to mark the individual sample vines along the row (Section 2.2). If so, place flagging tape around the lower third of the trunk so that it is visible when the canopy is fully developed. This task can be done in the weeks prior to crop measurement.

Step 2.1.2 Apply test treatments

Use your preferred method of scheduling in-vineyard tasks so that the test treatment is applied at the right time and with the correct technique.

If the test treatment is due to be applied mid to late flowering, for example, then monitor the progression of capfall. Record the actual E-L crop stage on the day of the test treatment, even if this is well after or before the planned crop stage.

If the test treatment is an application of fungicide or other crop protectant, then spray coverage should be checked. If the trial results show that the test treatment had no effect, then it could be due to poor spray coverage rather than the inherent efficacy of the spray material being applied. Remember, if an adjuvant is tank-mixed with the product being tested, then the test treatment is the 'product + adjuvant'. Indeed, the trial might be a comparison of product efficacy with and without the adjuvant. In any case, adjuvant type and rate should be recorded, along with spray (water) volume per hectare or per unit canopy row (canopy volume).

2.2 Gather data and observations

In this section we provide guidance on how to sample trial strips for data collection and recording. Consideration must be given to allocating and budgeting resources for data collation and analyses, and/or outsourcing the task, depending on in-house capacities.

Key considerations for collecting data and observations

1. Who will be responsible for data collection, analysis, interpretation and reporting? What budget can be allocated?
2. Will in-house staff need specific training?
3. Can some tasks be outsourced to a service provider?
4. Do you need to seek advice on how to sample and measure?

Step 2.2.1 Sample, measure and observe

Sampling unit

To measure the crop manually, then it is necessary to sample the crop at regular intervals along the row selected for crop assessment (see Step 1.2.1). If remote or on-the-go sensing is available, then every vine in the row can be measured.

If the canopy in an assessment row turns out to be atypical of other rows being assessed, then consider selecting a different row - either adjacent to the rejected assessment row or a row in another location in the block, where it makes sense to do so.

For manual sampling, the preferred method is single-vine sampling and a sample size of at least 25 vines along a vine row. This number of sample vines is needed for graphical presentation of moving window averages (refer to Step 2.3.2).

For ease of sampling, a single vine – the sampling unit - is defined as the area of canopy between one trunk and the next (Figures 2.2.1 and 2.2.2).

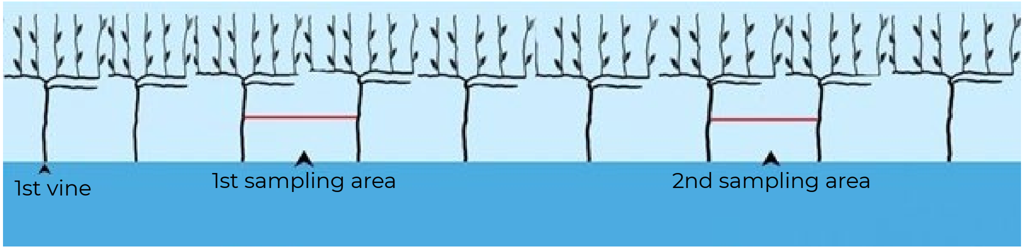


Figure 2.2.1 Schematic representation of the single-vine (trunk-to-trunk) sampling along a vine row. In this example, every fourth vine along the row is being sampled; however, the sampling interval might be shortened or lengthened depending on the number of vines per row.

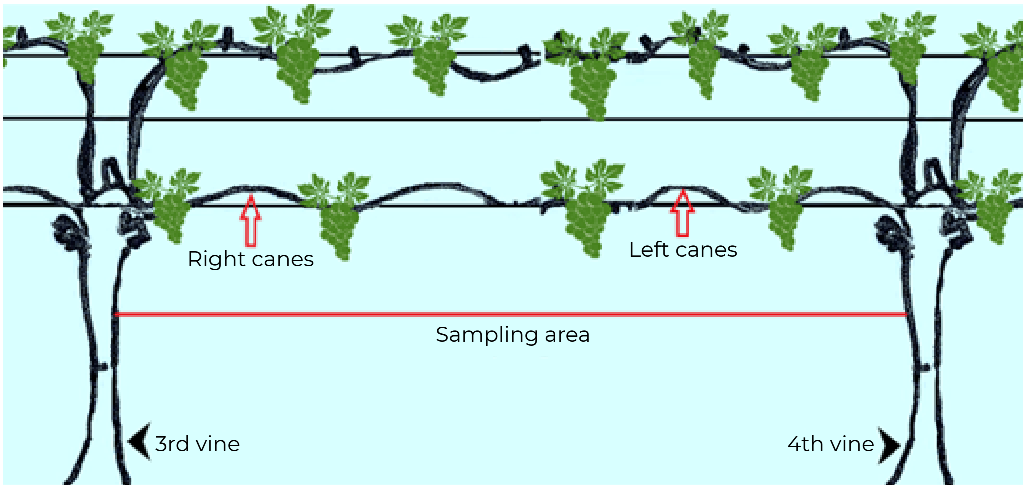


Figure 2.2.2 Schematic representation of the sampling area between two vine trunks. For crop protection trials, sampling eight grape bunches in the sampling area is sufficient to produce a reliable assessment of average disease severity (or incidence) per vine.

The sampling unit could be whole panel (or bay) of vines, if there are sufficient panels for the graphical presentation of results (Section 2.3).

For each vine sampled, the method of crop assessment will depend on the variable being measured. For example, eight grape bunches per vine are sampled arbitrarily for the assessment of botrytis bunch rot or powdery mildew severity per bunch (see Resource 1.2). Each grape bunch is given a score for disease severity, which is the area of the grape bunch with disease symptoms. The average disease severity per sample vine is then the average score for the eight grape bunches sampled. The grape bunches do not need to be removed from the vine for this assessment method.

There is an alternative method to sampling grape bunches arbitrarily if the fruiting zone is relatively narrow and there is no bunch crowding or clumping, for example, a single cordon or cane with well-spaced vertically positioned shoots. In this scenario, the per vine sample could be 10 grape bunches in a row, working from the trunk towards the (distal) end of cordon or cane. This sampling method may be helpful for vineyard workers who need clear and unambiguous instructions on how to sample grape bunches. Ideally, this method should be compared, in the first instance, with arbitrary sampling of grape bunches to ensure that trial results are equivalent when the same person (disease assessor) uses either method.

Sampling frequency

The aim is to sample at least 25 vines per row. Sampling commences at the third vine in the row, between the trunks of the third and fourth vine (Figure 2.2.2) and then continues at intervals that depend on the length of the row. The two end vines at either end of the row are excluded in case there are edge effects. Sample vines will be further apart in long rows relative to shorter rows.

For each assessment row, always walk in the same direction to sample vines e.g. north to south. That way, sample vines will be roughly in the same location in the row when comparing graphs for 'current practice' and 'test treatment', as described in Section 2.3.

If you reach a sample vine and find that the vine is missing or atypical (e.g. severely stunted), then choose an adjacent vine. However, resume the intended order of sampling for the next sample vine. For example, if sampling every fifth vine, you may have to skip vine 23 and assess vine 24; however, the next vine to be sampled would be vine 28.

To sample at least 25 vines per row, count the number of vines in the row, subtract the two vines at either end of the row, and then divide that number by an amount that will result in 25 or more sample vines.

Example 1

A row with 55 vines provides 51 potential vines for sampling once the end vines (2 x 2) are discounted. If 51 is divided by 2, then there are at least 25 sample vines which is the minimum number of sampling units per row. Thus, the sampling frequency is every second vine and the last vine to be sampled is vine 53 (Table 2.2.1)

Example 2

A row with 141 vines provides 137 potential vines for sampling once the end vines (2 x 2) are discounted. If 137 is divided by 5, then there are at least 27 sample vines, which satisfies the criterion of at least 25 sample vines. Thus, the sampling frequency is every fifth vine and last vine to be sampled is vine 138 (Table 2.2.1)

Table 2.2.1 Illustration of sample number per vine row for sites that vary in the number of vines per row. Every second vine is sampled in a row with 55 vines, whereas every fifth vine is sampled in a row with 141 vines to achieve at least 25 sample vines (sampling units) per row.

Trial site 1 55 vines per row		Trial site 2 141 vines per row	
Vine number in row	**Sample number**	**Vine number in row**	**Sample number**
3	1	3	1
5	2	8	2
7	3	13	3
9	4	18	4
11	5	23	5
13	6	28	6
15	7	33	7
17	8	38	8
19	9	43	9
21	10	48	10
23	11	53	11
25	12	58	12
27	13	63	13
29	14	68	14
31	15	73	15
33	16	78	16
35	17	83	17
37	18	88	18
39	19	93	19
41	20	98	20
43	21	103	21
45	22	108	22
47	23	113	23
49	24	118	24
51	25	123	25
53	26	128	26
55	Not sampled	133	27
		138	28
		141	Not sampled

Step 2.2.2 Record data

If the trial is assessed and sampled manually by walking along the trial strip, then use a suitable recording sheet fixed to a clipboard. Refer to Template 2.2.1 (or Resource 1.2.5) for an example of a recording template. Some wine businesses may use an in-house digital or phone application for data collection. The digital template may need to be adapted to suit the sampling scheme for this trial method.

A trial assessment can be completed faster with two people; that is, one person scores the crop or samples the bunches while the other records the score. If working alone, numbers might be recorded with the aid of your smartphone; however, you will need a very good coding system to allow accurate transcription of these numbers to an Excel worksheet later.

When using printed record sheets, it is preferable to record with a pen and not a pencil in case the recording sheet gets wet, or something causes the pencil marks to be erased. For blocks with vine netting, use a pen that does not have a side clip to prevent the pen clip catching on the vine netting. Carry a spare pen for the one that got dropped and lost in the grass!

In addition to key details such as row number and sample vine number, it is important to number each page in chronological order. Observations can also be added in the page margin. Note any unusual features such as a whole row or some panels with stunted or missing vines, infestations of pests, and so on. Take photographs, especially if there are visible differences between the current practice and the test treatment. Photographs can also be used to illustrate differences in fruit exposure, e.g., following leaf removal. Such differences may be easier to see if a blue sheet or board is held behind the vines in the row being photographed.

Scan your recording sheets as soon as your return to the office and file them in digital folder that is routinely backed up.

Template 2.2.1

This template is a **data recording sheet** for disease severity (e.g. botrytis, mildew) for 8 grape bunches per sample vine and for up to 27 sample vines per row. A similar template can be prepared for other crop variables.

Assessor	________	Block	________	Time start	________
Recorder	________	Row	________	Time end	________
Date	________	Side of row	________	Page No.	________

No	Vine No.	Severity estimate (%)							
		Bunch1	2	3	4	5	6	7	8
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									
13									
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16									
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24									
25									
26									
27									

2.3 Analyse data and report

The viticultural world is replete with examples where trial data and observations have been collected meticulously and then filed, never to see the light of day again.

In this section we describe the straight-forward calculations underpinning graphical presentation of trial results. While an attempt has been made to simplify the process, consider the need to allocate and budget time for this activity, and/or outsourcing the task in the absence of in-house capacities or capabilities.

Key concepts for data analysis and reporting

1. Rigour is introduced through calculation of moving window average of multiple measurements along a trial strip to visualise spatial variability in the crop's response to the test treatment.
2. Row-by-row comparisons of moving window averages between the test treatment and current practice provide information about the magnitude of the difference in different locations in the trial strips.
3. Calculating the average effect for the whole row (trial strip), while interesting, misses the opportunity to understand how the numbers vary according to the location in the vineyard row.

Given that in-vineyard trials are directed to business decision making, statistical analyses of data are not the primary means for interpreting trial results. Nonetheless, some people might want to know if there is a significant (statistical) difference in the average effect between the test treatment and current practice. If so, a two-sample parametric or non-parametric statistical test, can be performed by those who know how. Refer to a statistician or biometrician for advice on the most appropriate two-sample test.

Step 2.3.1 Do the calculations

Enter data from recording sheets used in the vineyard and/or import data to an Excel spreadsheet. Refer to the worked example listed in Resource 2.3 for ideas on how to set up the Excel spreadsheet with suitable row and column headings.

With the aid of the spreadsheet, calculate the average value for each sample vine when multiple grape bunches per vine have been assessed.

Calculation of moving window averages

Here we describe a set of calculations underpinning the preferred means of presenting trial results; that is, a graph of moving window averages for each vine row in which the crop's response was assessed.

A moving average is a calculation that creates a series of averages for different selections of the data in an ordered sequence. For trial strips, this means using each average value per sample vine, deciding the size of the moving window, and then calculating a series of moving window averages in the Excel spreadsheet as illustrated in Figure 2.3.1 and Table 2.3.1. Again, refer to the worked example listed in Resource 2.3 for the moving window average calculations.

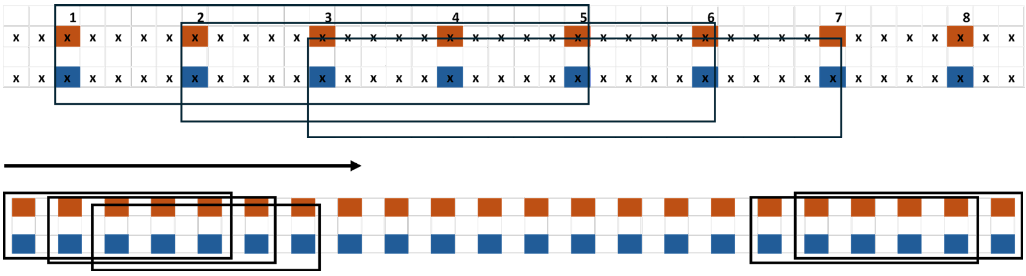


Figure 2.3.1 Illustration to aid understanding of moving window averages. Every coloured square represents the average value per sample vine (orange for current practice; blue for test treatment). Every fifth vine along the row was sampled (top panel). The mean value for the first five sample vines is calculated (bottom panel) based on a decision that the window size would be five values. The window is then shifted by one sample vine to calculate the mean value for the next five sample vines, and so on, until the final window is the five sample vines near the end of the row. The size of the 'window' can be varied depending on how much the data needs to the 'smoothed' for graphical presentation (see next step).

Table 2.3.1 An example of moving window averages for a vine row used for disease assessment in a trial strip (row 12 in Figure 2.3.2 below). Every third vine was sampled and a window of five was used to calculate moving window averages. Resource 2.3 is a worked example showing the full set of calculations.

Sample number	Vine number in row	Average botrytis severity per vine (n = 8 bunches)	Moving window average (y-axis in graph)	Moving window number (x-axis in graph)
1	3	0	1.925	1
2	6	3.125	1.925	2
3	9	2.75	2.175	3
4	12	0	1.625	4
5	15	3.75	3.5	5
6	18	0	4.875	6
7	21	4.375	5	7
8	24	0	4.375	8
9	27	9.375	5.375	9
10	30	10.625	4	10
11	33	0.625	2.25	11
12	36	1.25	2.5	12
13	39	5	2.5	13
14	42	2.5	1.5	14
15	45	1.875	2	15
16	48	1.875	2.8	16
17	51	1.25	3.55	17
18	54	0	4.3	18
19	57	5	5.175	19
20	60	5.875		
21	63	5.625		
22	66	5		
23	69	4.375		

Step 2.3.2 Prepare the graph of results

Prepare a graph of the moving window averages by plotting each moving window average (y-axis) against the corresponding moving window number (x-axis).

The graph should include information about the number of vines per row and the interval between samples (e.g. every fifth vine) to aid interpretation of spatially variable crop responses.

Figure 2.3.2 shows a graph including the values for both the test treatment and the current practice. These trial results reveal the magnitude of the difference between the test treatment and current practice at corresponding locations along each assessment row. If the trial strips have been positioned well, then these results should reflect the range of performance of the test treatment relative to current practice in other areas of the vineyard block. The number of vines per row and the interval between samples (e.g. every fifth vine) should be reported to aid interpretation of spatially variable crop responses.

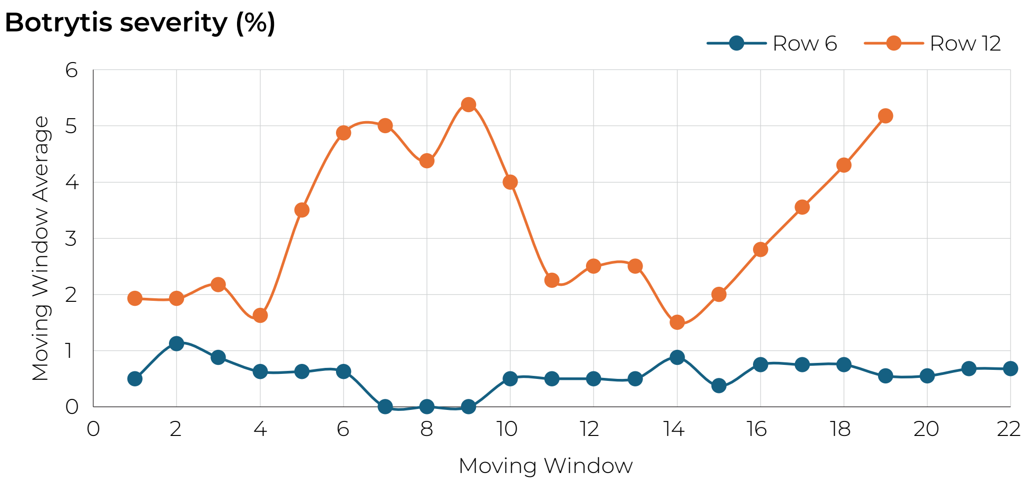


Figure 2.3.2 Comparison of moving window averages for botrytis bunch rot severity in rows 6 and 12 in a block of Riesling vines in Tasmania on March 20, 2024. Vines in row 6 received the vineyard's normal spray program (current practice) and vines in row 12 received the same program except that one fungicide product was omitted during the flowering period. Using a window of five sample vines, row 6 provided 22 moving windows from 26 sample vines and row 12 provided 19 moving windows from 23 sample vines.

Transfer graphs to a Word document that will be used in due course to report the trial results. A graph prepared in an Excel worksheet can be transferred to a Word document using 'copy' (the graph in Excel) then 'paste special' (to the Word document) using the menu option 'picture (enhanced metafile)'. The picture can then be resized, as needed.

Resource 2.3

#	Title	Description
2.3	*Moving Window Average* available from http://bit.ly/42POBdj under the Resources tab	A spreadsheet showing the set of calculations for moving window averages from a hypothetical set of disease data.

2.4 Interpret results and draw conclusions

In this section we discuss the interpretation of trial results and conclusions that can be drawn from them. Trials do not always result in a clear and large difference between the current practice and the test treatment, nor at all locations along a trial strip. The underlying reason is that the crop's response to treatment is spatially variable. The pattern of spatial variability in the crop's response may also differ between the test treatment and current practice.

Step 2.4.1 Describe the results

The following four trial scenarios illustrate potential ways to describe trial results. Keep in mind that shorter rows will have a finer spatial resolution of data simply because more vines are sampled for a given length of row.

Scenario 1

Refer to Trial number 1 in Table 2.4.1.

In this scenario the line for the test treatment is consistently above that of the line for current practice. Given this result, the next step is to decide whether the magnitude of the difference between the test treatment and current practice is useful in practice. Alternatively, the results could be interpreted according to a predetermined threshold for disease severity, above which the level of disease control would be considered unacceptable.

The trial results might be described as follows: "There is a clear and practical difference is disease severity between the test treatment (row 6) and current practice (row 12) at all locations along the rows used for disease assessment. Current practice reduced disease severity below the critical threshold of 3% whereas omission of a critical spray timing (the test treatment) resulted in disease severities greater than 3% for nine of the 19 moving window averages."

Scenario 2

Refer to Trial number 2 in Table 2.4.1.

In this scenario there is a clear difference between the test treatment and current practice but not at all locations in the trial row.

The results might be described as follows: "The test treatment (row 31) resulted in lower disease severities than the current practice (row 44) for the first seven moving window averages in the row; however, there was little difference in the averages for the remainder of the row. The average disease severity for row 44 (1.7%, current practice) masked the fact that moving window averages were highly variable, ranging from 0.25 to 4% severity. In contrast, moving window averages for the test treatment were 0.1–1.5% and less variable."

Scenario 3

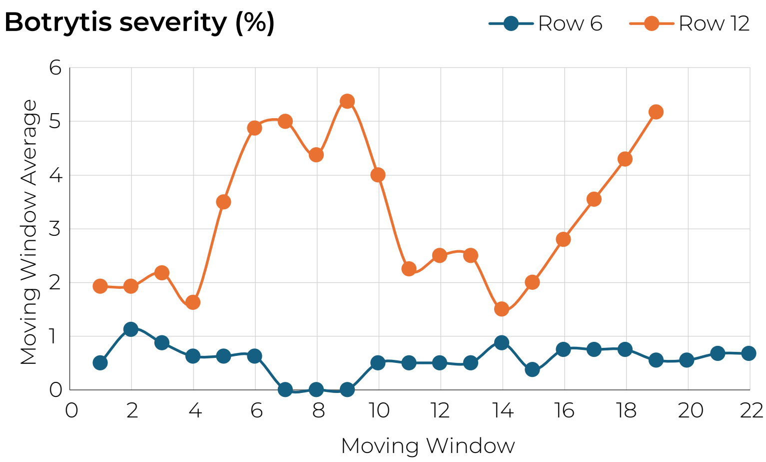
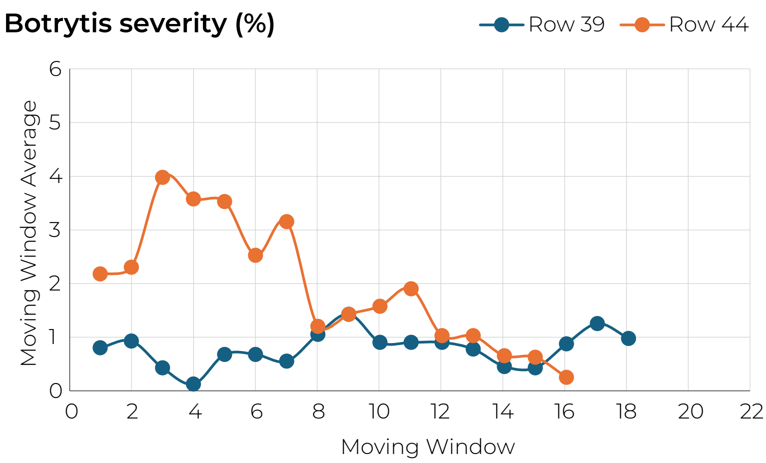
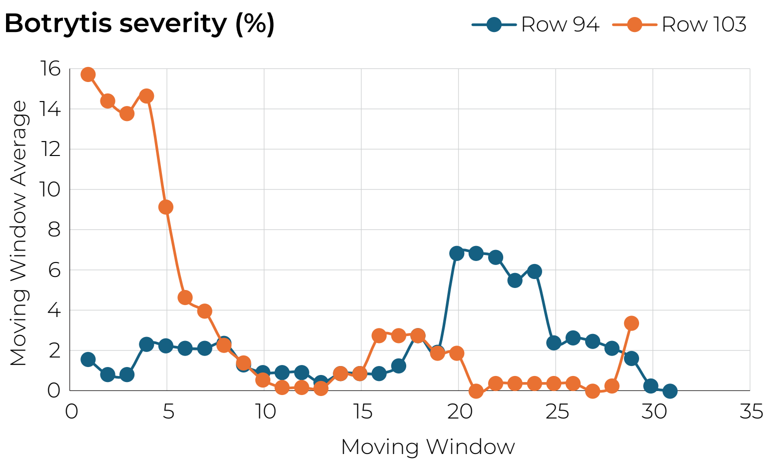
Refer to Trial number 3 in Table 2.4.1.

In this scenario there were no discernible differences in the crop's response between the test treatment and current practice at most locations in the row. However, the first five moving window averages reveal differences in the crop's response; that is, disease severities were greater than 8% severity for row 103 and less than 3% severity for row 94.

Scenario 4

In this scenario trial results are not presented due to issues relating to inappropriate or problematic trial design, positioning and/or implementation. In other words, the trial results were inconclusive, and the trial question could not be addressed.

Table 2.4.1 Examples of trial results. The y-axis on the graphs is the moving window average severity of botrytis bunch rot (%) and the x-axis is the moving window number at different locations along the trial strip. The statistical test was a nonparametric Mann Whitney U test (one-tailed) with an equal sample size, included here for those who are interested in the results of statistical tests.

Trial number	Trial results	Moving window averages
1	Mean severities per row: Row 6: 3.2% Row 12: 0.6% Mean botrytis severities (whole row) were significantly different at *P* = 0.0004.	
2	Mean severities per row: Row 39: 0.9% Row 44: 1.7% The difference in mean botrytis severities (whole row) was marginally significant (*P* = 0.059).	
3	Mean severities per row: Row 94: 2.1% Row 103: 3.8% Mean botrytis severities (whole row) were not separated statistically (*P* = 0.1047)	

Step 2.4.2 Interpret results and draw conclusions

Conclusions can only be drawn if the trial has been designed and implemented sufficiently well to produce a conclusive result.

Use the flow diagram in Figure 2.4.2 to aid interpretation of trial results that in turn inform subsequent decisions.

Interpreting crop protection trials

When the target pest or disease does not develop to any significant degree in the trial area, and in the absence of a non-treated trial strip, then one conclusion is that the current practice and the test treatment are interchangeable under the specific seasonal conditions of the trial. In this situation, there is no way of knowing how the test treatment will perform in subsequent seasons. Remember the truism that sprays work best when they are not needed. However, there can be comfort in having spray coverage when the weather ahead is unknown.

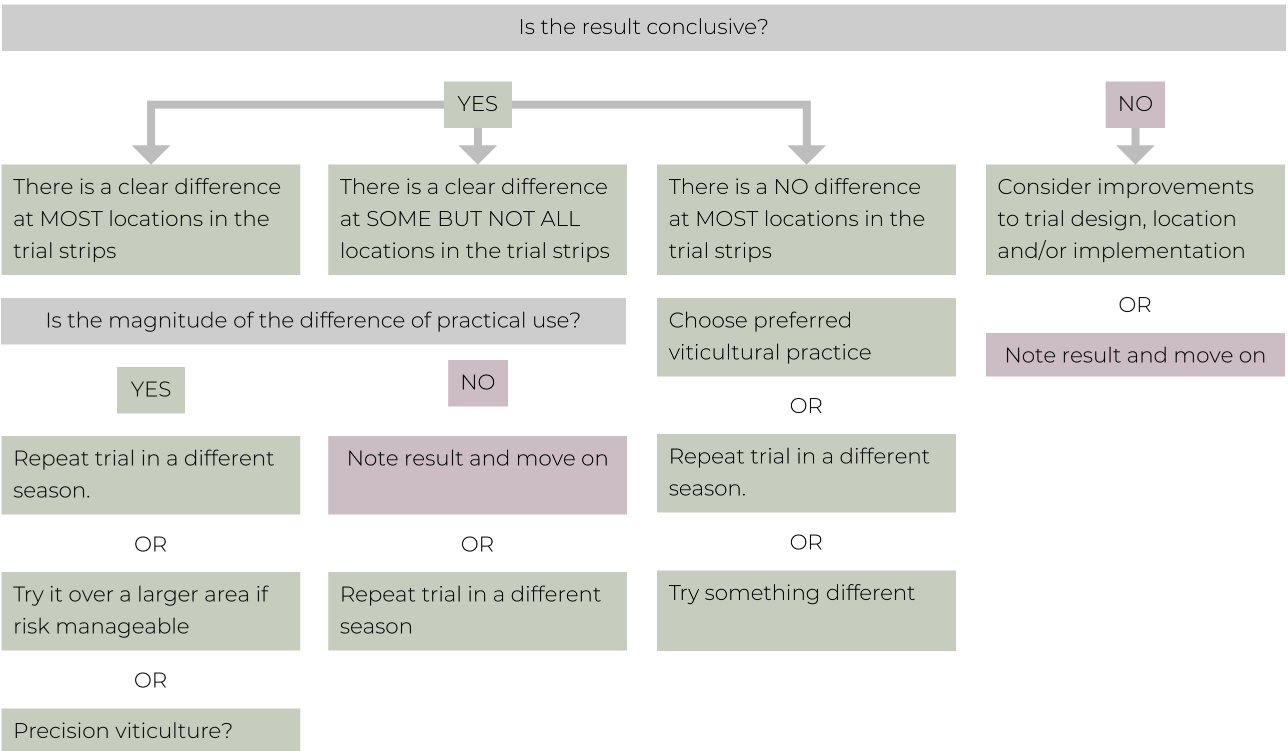


Figure 2.4.2 Interpretations of trial results and potential decisions flowing from them. Refer to Module 4 for elaboration of precision viticulture in relation to in-vineyard trials.

If the test treatment reveals a small gain relative to current practice, involving others in the discussion of these results might reveal the opportunity to combine the test treatment with other viticultural practices to see if there are additive or synergistic effects. Such conversations will likely shape the next trial to be conducted. Seek help from relevant experts when needed.

It is important to communicate and discuss the trial results with those who have a vested interest in how the grapes are produced or processed. Involving people such as the winemaker or general manager can aid interpretation of the results from a broader business perspective. Looking at the trial results together can also provide an important opportunity for broader conversations that can help an operations manager to secure budget allocations for in-vineyard improvements, whether or not these are informed by the trial results.

2.5 Plan next steps

Once you have interpreted the results of a trial with relevant others and decided on a broad course of action, then develop a plan for the next steps.

Use Template 2.5 to plan what action you will take next. Actions might include planning the next trial, ordering a crop input for next season, or simply making a phone call to get more information.

Template 2.5

Template 2.5 Action plan after trial completion. Start a new template for each new action.

Item	Description
Task	
When and where?	
What do I need to find out or do to get this job done?	
Who needs to be involved or contacted?	

Comments

MODULE 3

I'm a service provider. How can I help?

A producer-led trial is one where the producer's needs are placed front and centre. This module provides practical tips and hints for service providers so that they can be effective in providing support and services to producers as they plan and implement a trial. Producers may wish to read this module to consider how best to involve others in the trial.

Key points

- Develop indicators of success for you and your client.
- Understand and respect farming style and drivers of on-ground decisions.
- Communicate using the right mode at the right time and with empathy, respect and humility.
- Discuss and manage risks associated with your joint activities.
- Prepare instructions that integrate well with existing operations.
- Understand the fine line between being helpful and not overly helpful.
- Adapt-on-the-go in line with changes to operational conditions.
- Understand learning styles and preferences when delivering information.
- Evaluate the collaboration: was it effective, efficient, informative and respectful of all participants needs?

3.1 What is your role?

A rigorous, producer-centric trial requires the integration of different types of knowledge and know-how, including the expertise you bring to the process. Your services may be recruited for stand-alone activities, such as data analyses and preparation of trial results, or you may work co-operatively with the producer to implement some aspect of the trial. Whatever your role, collaboration will occur on some level; for example, a trial report cannot be prepared without the producer contributing key details. Thus, a successful trial is one where the collaboration is effective, efficient and respectful of all participants' needs.

3.1.1 Adviser or coach?

Whatever your role, it is important to abide by the principle that the producer has ownership of the trial regardless of their capabilities and capacities to undertake trial activities. In this context, consider when you need to be an adviser and when you need to be a coach. Does the producer want you to be the out-sourced hired help, or do they want your support to coach them through one or more aspects of the trial? Such conversations can reveal where your expertise needs to be deployed which, in turn should be reflected in a formal or informal service-level agreement.

Have you ever bent over backwards to help someone only to realise that they have become dependent on you next time the same situation arises? When coaching, there is a fine line between being helpful and not being so helpful that your intervention is ultimately unhelpful. One way to locate the invisible line between over delivery and under-delivery is to set clear indicators of success. What would you like your client to be hearing, seeing and doing as an outcome of your service delivery? What goals are you trying to achieve for your own business and any other individual or group that has a stake in the work? Being clear on the outcomes of your interaction with a producer will help shape how you work together as much as what is produced during the collaboration.

3.2 Effective communication

Timely and effective communications are critical. Understand the producer's preferred means of communication; for example, email may be checked infrequently yet can be used when you need to share some detail, or the query is non-urgent. Perhaps your query is better directed to someone else in the business. Know 'who's who' in the business and what (often hidden) role they might play.

Think about good times of the day to make a phone call, including rainy or windy days when people might be office bound. Don't expect full or meaningful answers to your questions when the producer is trying to fix the harvester at a time when all the fruit is coming thick and fast, if indeed they answer your phone call.

3.2.1 Respect, humility and empathy

Producers draw upon their experiential knowledge when setting the trial question to answer business-specific questions. They necessarily play a critical role in decisions to adapt trial methods according to seasonal conditions or operational needs. Experiential knowledge is fundamental to trial success, so it deserves to be recognised and integrated into the trial respectfully.

As you draw upon a producer's knowledge, they may also need specific help to integrate the information and expertise you bring to the trial process. Knowledge exchanges will be most successful when you, the expert in your field, are modest, humble and authentic in your delivery of ideas and information. "Don't be such a bl**dy expert!" is the classic Australian expression that comes to mind when dealing with someone who is a bit too enamoured with their own ideas.

The minute you enter a vineyard you are no longer the expert when it comes to understanding the land, the environment and the people involved in producing the crop. Similarly, the producer expects you to answer only those questions for which you know the answer. You are more likely to earn respect if you say you do not know the answer then offer a practical pathway for the producer to find the information or advice they need.

Empathy is critical. On-farm decisions are not always rational and may be driven by fear, anticipation of impact, logistical nightmares in the making, or any other event toying with the decision-maker's emotions. There may be times when you feel frustrated if you think there could have been a more logical or scientific approach regarding trial conduct; however, it is important to remember that we cannot always know the reasons behind a producer's actions or thinking.

It is important that we respect a producer's decisions if we are to build empathy and trust in the working relationship. Respect is often about listening to what another is saying. Listen and learn what is going on in their world. Empathy also helps us decide the right time, place and mechanism to influence a decision. Working in this way - with respect, humility and empathy – helps to generate reciprocity; that is, the exchange of knowledge, materials and know-how for mutual benefit.

3.2.2 Giving clear instructions

The trial plan, and/any modifications to it, should be prepared for ease of interpretation by the operations manager, who in turn may need to give clear instructions to vineyard workers. For example, if the test treatment is a multi-step process, then it is important to list actions to be taken in the vineyard in chronological order. For example, leaf removal by hand may be required several weeks before an alternative fungicide is tested. If necessary, the plan should alert the operations manager on when to organise workers or hired labour to complete canopy manipulations ahead of the spray application.

Unlike researchers, producers tend not to think about the testing of a specific pesticide or fungicide in isolation of the entire spray program. For example, the mid-flowering spray may comprise a tank mixture of fungicides for botrytis, powdery and downy mildews. If the test treatment is a change to the botrytis fungicide used, then the materials for powdery and downy mildew still need to be applied over the entire area of the vineyard block. Therefore, it can help to list the entire, planned spray program in the trial plan and highlight where changes to the program are being made. There may need to be some additional instructions to ensure rows of the test treatment receive all the required spray materials.

A trial will sometimes explore changes to spraying technique. Any adjustments to water volume per ha, for example, can lead to challenges in adjusting concentration factors and the amount of product per 100 L. Consider also that the final amount of product per ha may exceed limits specified by product labels and/or those purchasing or processing the grapes. Either seek advice from an expert in spray technology and/or discuss with the producer the benefit of having someone check spray calculations prior to implementing the test treatment.

3.2.3 Liaison during the trial

While it is the producer's responsibility to implement test treatments and collect relevant viticultural information such as key crop stages, a collaborating service provider or technician can add value by monitoring what is going on, keeping their own journal of observations, and providing prompts to and/or act a sounding board for the producer as needed. Being on site or on the phone during key activities of a trial can aid effective implementation and/or adjustments that improve trial outcomes.

A critical time to contact a producer is immediately prior to implementation of a test treatment where there may be some complexities associated with the operation. For example, it may be helpful to check plans and calculations for spray volumes or product amounts for an imminent spray application, or the logistics of how various tank mixtures will be applied in practice. Similarly, it can be useful to check-in with the producer at critical crop growth stages, such as pre-flowering and during flowering, to ensure crop stages relevant to the trial are being recorded. Take the opportunity to record the crop growth stage during every site visit as it is not unusual for your own assessment to vary from that reported by the producer. Keep in mind that crop stages reported in spray diaries are sometimes the intended crop stage rather than the actual crop stage when a spray was applied.

A critical time to maintain a high level of communication with the producer is in the weeks leading to harvest. Snap decisions about the date of fruit picking are common depending on winery logistics, sudden decisions to change the end use of the fruit (e.g. from table to sparkling wine) and/or forecasts for imminent and potentially destructive weather. Indeed, the operations manager may not know the harvest date until the very last minute. Understand who makes the decisions about harvest date and/or how the operations manager is informed; for example, is there a whiteboard in the winery that lists plans for the coming week? Are these just ideas or solid plans?

Importantly, do not wait for or assume that the operations manager will call you to advise on the harvest date. Communications about harvest date might be initiated by phone calls, commencing weekly or fortnightly and then increasing in frequency when it feels like there is more certainty about the harvest date. Importantly, keep phone calls or text messages brief and to the point during busy times in the vineyard. There are likely a dozen other people asking the operations manager the same question! Finally, be ready to travel to the site at short notice in case there is a need to complete the disease assessment ahead of the pickers or machine harvester. Follow formal sign in and biosecurity protocols when entering a vineyard. Good practice includes washing boots before entry, letting the manager know you are on site (e.g. by SMS or a check-in App), and wearing a fluoro safety vest so you can be seen by vineyard workers who may be operating machinery in the vicinity.

3.3 Pre-trial activities

3.3.1 Focus groups

If a group of producers in a particular locality have never used this trial methodology, then a focus group or workshop prior to commencement of the season in which trials are planned can aid learning about the approach and what it involves. Hearing from a respected producer who has benefitted from trials of this type can help motivate people to try the approach. Participants can also be directed to on-line resources that help them learn at their own pace.

Producers who are already familiar with the trial methodology may prefer one-on-one interactions when seeking expertise for trial planning and implementation. As always, be guided by the producers you are working with on how they want to interact with you and with other producers.

3.3.2 Site visits

Visit the vineyard well before the trial commences to confirm your role and to understand or facilitate development of trial objectives, test treatment/s, potential trial layout and other aspects of trial design. Template 3.3 provides a checklist that can be used or adapted to suit the context in which the trial is being conducted. Discussions should also reveal the need to alter any previous or preliminary plans, and how that might impact, or not, the integrity of trial outcomes.

3.3.3 Risk assessment and contingency planning

While the goal of a test treatment is to improve viticultural outcomes or to find a more cost-effective solution, unintended or negative outcomes can occur. It is vital to consider financial, reputational or other risks associated with the trial and your role as a trial collaborator so that pro-active steps can be taken to mitigate these to an acceptable level.

Discuss with the producer the potential for crop loss or downgrading of fruit quality and what degree of loss, if any, will be tolerated. A producer-led trial is not like commercial R&D where compensation for crop loss might be expected. Moreover, the winemaker or grape buyer may be expecting to receive a certain tonnage of grapes to ensure continuity of supply to valued customers. Therefore, it is important to help the producer assess the risks of a test treatment, including crop protectants or biological products where efficacy may not be well understood.

Develop awareness of potential situations or events that will require on-the-go adaption of trial methods. Potential events that may have an impact on the issue being addressed by the trial, and/or trial assessment include:

- an earlier than planned harvest date or a change to the intended end-use of the fruit,
- selective harvesting of grapes within sub-sections the trial area, including parcels of fruit that are harvested on different dates,
- removal of mouldy fruit in botrytis trials in the days prior to the main harvest date, and/or
- fruit are not harvested due to unacceptable quality, fruit injury and/or the economics of processing the fruit.

Discuss backup or contingency plans for unexpected events such as extreme weather events, pest outbreaks, other crop damage, loss of critical personnel or equipment failures. Discuss upfront the criteria for when a trial should be abandoned. This may also include taking into consideration day-by-day decision-making in the pre-harvest period, especially for diseases like botrytis bunch rot.

Template 3.3

1. Grower and business details

- ☐ Vineyard manager's name
- ☐ Mobile number and email address
- ☐ Employee or Business Owner?
- ☐ Business name and ABN
- ☐ Postal address

2. Site details

- ☐ Vineyard size (ha), location and viticultural region
- ☐ Maintenance of weather stations (if any); sensor types and height above ground; how weather data can be accessed.

3. Block-specific information

- ☐ Name/number of the block?
- ☐ Current crop stage?
- ☐ Location within the vineyard?
- ☐ Total area (ha) of the block?
- ☐ Describe the aspect of the block and landscape features (e.g., slope, elevation).
- ☐ Variety/varieties planted?
  If a single variety, is there more than one clone? Which rows?
- ☐ Trellis system?
- ☐ Pruning method? (spur, cane)
- ☐ How are vine rows oriented? (north-south, east-west)?
- ☐ Distance (m) between rows?
- ☐ Distance (m) between vines?
- ☐ Disease and pest history?
  (main issues, losses in recent seasons, location of disease hot spots)?
- ☐ Any plans to test spray coverage?
- ☐ Intended use of grapes, if known (e.g., table wine, sparking wine, wine style)
- ☐ What approach is being taken for crop protection and other crop inputs?
- ☐ Is there a written plan for the spray program or other crop inputs?

4. Trial-specific information

- ☐ What is the key issue, challenge or opportunity that you want to address?
- ☐ What do you want to learn? What would you like to test or explore?
- ☐ **For those who conducted a trial in the previous season:**
    - What did you learn from the trial last year? What needs to be tested or retested this season? For what purpose?
- ☐ What will be the test treatment and how does that different from current practice?
- ☐ Is there a need to repeat the trial strips in multiple locations in the block? e.g. for short rows or across-row spatial variability
- ☐ Are buffer rows needed? If so, how many rows will be allocated to the test treatment or current practice? For small blocks: can these be accommodated?
- ☐ What colour of flagging tape will be used to mark the test treatment?
- ☐ Which rows in each trial strip will be assessed?
- ☐ Will the grower assess their own trial? If yes, what support, if any, is needed? What is the back-up plan if the grower runs out of time to assess the trial?

Repeat similar questions for additional test treatments (if applicable).

5. Risk assessment and next steps

- ☐ What are the risks, if any, in conducting this trial? How will these risks be managed or mitigated?
- ☐ Does the grower have any additional information or concerns relating to the trial that they would like to discuss?
- ☐ When and how would the grower like to follow up on what was discussed today? (Agree on next steps e.g. after sending a draft version of the trial plan)?

3.5 Post trial activities

Trials are an ideal means for producers in a locality or region to share knowledge around common issues. Well-facilitated focus groups of producers provide action-learning opportunities and may involve institutional or commercial providers who bring specific expertise in trial design, data collection and/or interpretation of results.

A post-season workshop attended by wine businesses who are using the trial methodology can help them reflect together on the immediate past season while they learn about the trials of others. Having a common language and use of words where there is no ambiguity in meaning can greatly enhance exchanges in knowledge. 'Current practice' and 'Test treatment', for example, are key phrases in the context of a producer-led trial.

Workshop discussions can reveal common operational challenges beyond the conduct of trials, thus reminding participants that they are not alone in facing these. Allowing free-flowing exchanges at key moments in a workshop can help group members prompt each other about the need and value of basic viticultural practices that may have lapsed during the busy-ness of in-season activities.

A post-season workshop can conclude with a dedicated session to help individuals develop their next trials. If so, each participant can be provided with a worksheet like Template 2.5 to develop their own action plan. After completing the plan, even if only a few rough notes, encourage participants to place their plan in a self-addressed envelope. The workshop convenor can then post the plan to each participant two weeks later. Receiving one's own action plan in the mail is a great prompt and call to action.

3.6 Evaluating the collaboration

During and after collaborating with wine business staff and/or other service providers it is worth reflecting on and evaluating whether the collaboration was effective, efficient, informative and respectful of all participants needs. Here we refer again to Figure 1.0.1 in Section 1 to emphasise the importance of stopping to reflect during the trial to consider what might be changed or improved for better outcomes. Reflection on our individual and collective work can lead to continual improvement. It also provides space for conversations that help solve issues early and/or seize opportunities that be opaque when working in isolation.

One of the most effective and efficient means to evaluate our collective work is to simply make the time to have 'the' conversation with each other. We recommend a semi-structured conversation and nominating one person to organise and facilitate a dedicated meeting for this purpose. A semi-structured conversation involves developing a series of questions that people can view and consider before a meeting where they discuss their answers. In the meeting, individuals can choose to share all their reflections or only some of them. The group can also decide pro-actively on the frequency of such conversations or to time them at key junctures during and after the trial.

We use the **ORID** technique[9] to structure a conversation with **O**bjective, **R**eflective, **I**nterpretive and **D**ecisional questions. Refer to Template 3.6 for an example of questions relevant to evaluating a trial collaboration. The **ORID** technique can be applied to all forms of teamwork – at work, at home and at play (e.g. sports teams). Stopping regularly to reflect and consider how we interact with each other, and the associated constraints and enablers, is also a means to build strong working relationships.

[9] Stanfield, R.B. (2014) The Art of Focussed Conversation: 100 Ways to Access Group Wisdom in the Workplace. The Canadian Institute of Cultural Affairs, Toronto, Canada and New Society Publishers, BC, Canada. 222 pages.

Template 3.6

A selection of **O**bjective, **R**eflective, **I**nterpretative and **D**ecisional (**ORID**) questions to aid collective evaluation of the collaboration. Each collaborator considers their responses before discussing only those responses they wish to share. When considering each question, write or discuss whatever comes to mind first, not necessarily in the order presented below.

Objective questions

Describe your role during the trial. What actions did you take?

Who else was involved in the trial? What role did they play?

What activities did or did not go to plan? What happened?

What activities were changed or adapted?

Reflective questions

How did the trial impact your day-to-day activities and/or those who work with you?

What challenged you?

What surprised you?

Interpretive questions

What was the most meaningful or useful aspect of doing this trial?

What insights do you think you will need to remember?

What can you take from this experience to best serve your needs or the needs of those who work with you?

What can you conclude from the experience of doing this trial?

Decisional questions

What will you do next with these insights?

What will you start doing? What will you stop doing?

How will you go about making the changes you identified?

For the client:

What more (or less) do you need and/or expect from me, your service provider?

MODULE 4

How can digital tools add value?

This module provides case studies to illustrate how digital tools, especially those used for precision viticulture[10] (PV), can aid the positioning of trial strips, increase efficiencies in data generation, contribute to rigorous interpretation of trial results, and/or highlight opportunities for viticultural interventions. This module is necessarily future focussed and considers William Gibson's statement that: "*The future is already here – it's just not evenly distributed*."

Key points

- Trial strip positioning can be optimised by use of a land feature (e.g. elevation) or a vegetation index that covaries with the crop attribute of interest (e.g. yield, disease severity).
- Appropriate trial positioning using PV tools can minimise the number of trials needed across growing seasons to understand the full range of crop responses to a test treatment.
- Case studies are used to illustrate the use of covariates in generating and interpreting trial results.
- When the treatment effect *is less than* spatial variability associated with features of the land then addressing such variability may be more productive than doing more trials.

It is acknowledged that specific skills and knowledge are required to apply PV and related digital tools. It is also assumed that there will be increasing access to remotely sensed data (type, amount) and capacities to apply PV tools[11]. Even so, effective integration of these tools within a farming system, to support on-farm experimentation and operational decisions, requires consideration of factors influencing uptake and use – factors that are beyond the inherent features of the technologies[12] [13] [14].

[10] Proffitt, T., Bramley, R., Lamb, D. and Winter, E. (2006) *Precision viticulture: a new era in vineyard management and wine production*. Ashford, Australia: Winetitles Pty Ltd.

[11] Song, X., Evans, K. J., Bramley, R. G. V. and Kumar, S. (2022) Factors influencing intention to apply spatial approaches to on-farm experimentation: insights from the Australian winegrape sector. *Agron. Sustain. Dev.*, **42,** 96. https://doi.org/10.1007/s13593-022-00829-w

[12] Bramley, R. G. V., Song, X., Colaço, A. F., Evans, K. J. and Cook, S. E. (2022) Did someone say "farmer-centric"? Digital tools for spatially distributed on-farm experimentation. *Agron. Sustain. Dev.,* **42**, 105 https://doi.org/10.1007/s13593-022-00836-x

[13] Lacoste, M., Bellon-Maurel, V., Piot-Lepetit, I. *et al.* (2025) Farmer-centric On-Farm Experimentation: digital tools for a scalable transformative pathway. *Agron. Sustain. Dev.,* **45**,18 https://doi.org/10.1007/s13593-025-01011-8.

[14] Evans, K.J., Terhorst, A., Kang, B.H. (2017). From data to decisions: helping crop producers build their actionable knowledge. *Critical Reviews in Plant Sciences*, **36**, 71–88. https://doi.org/10.1080/07352689.2017.1336047

4.1 Positioning trial strips

In Section 1.2, we introduced the concept that a trial strip will ideally capture close to maximum variability in the crop's response. Critical to the application of PV tools for positioning trial strips is knowledge of how a crop attribute (e.g. yield) co-varies spatially with other variables that can be measured readily using on-the-go or remote sensing[15]. Examples include vegetation or 'vigour' indices and variables derived from soil survey data or topographical features such as elevation. These variables are 'covariates' when it has been established that the spatial pattern of the crop attribute of interest (e.g. yield) and its co-variate are similar and stable from one season to the next. Therefore, a map illustrating spatial variability in a covariate can be used to position a trial strip.

Those with technical knowledge about PV can refer to the protocol of Song *et al.* (2023)[16] which describes the use of PV tools to position trial strips. An alternative approach is to use a map of predetermined management zones to ensure the trial strip traverses all identified management zones or categories of a known co-variate such as plant cell density. Sufficient vines should be sampled in each management zone prior to analysing how the crop attribute of interest varies within and among management zones.

4.1.1 Use of multi-season data

Seasonal conditions can impact the magnitude of the difference between the effect of a test treatment and current practice. This situation is especially true for crop protection trials. Extreme weather conditions – either extremely favourable or unfavourable for pest and disease development – can result in similar average effects for the test treatment and current practice. That is, all treatments in extreme conditions may fail to limit severe pest or disease or, at the other extreme, the pest or disease is largely absent. In contrast, a significant difference between the effect of the test treatment and current practice may be evident when the weather is moderately to highly favourable for the pest or disease.

Maps of the spatial pattern of pest or disease severity, or a covariate, from multiple seasons can be overlayed to see if spatial patterns are stable over time even though the magnitude of pest or disease severity varies according to the season. Such knowledge should help identify optimum positioning of trial strips in any given season and capture those locations where a difference, if real, will be detected. The benefit of appropriate trial positioning using PV tools is that the number of trials needed to understand the full range of crop responses to a test treatment is minimised. As discussed previously, use weather-based descriptors of pest or disease risk can also aid interpretation of the trial results (Section 2.2).

[15] Song, X., Bramley, R. G. V. and Evans, K. J. (2023) A method to position a simple strip trial to improve trial efficiency and maximise the value of vineyard variability for decision-making. *OENO One*, **57,** 97-107. https://doi.org/10.20870/oeno-one.2023.57.1.5542

[16] Song, X., Bramley, R. G. V. and Evans, K. J. (2023) A method to position a simple strip trial to improve trial efficiency and maximise the value of vineyard variability for decision-making. *OENO One*, **57,** 97-107. https://doi.org/10.20870/oeno-one.2023.57.1.5542

4.2 Generating and interpreting results

The human eye is a highly effective sensor for visual assessments of canopy or fruit attributes. Nonetheless, remote sensing introduces efficiencies, and the opportunity to overlay imagery of multiple and spatially variable crop and land attributes. The next three examples, illustrate the use of remote sensing and co-variates to aid data collection and interpretation of trial results.

4.2.1 Case study 1 – compost trial

During Song's collaborative research[17], the co-operating producer was interested to know the effect of applying compost on winter vine pruning weights (kg/vine). Winter pruning weights are an indicator of seasonal canopy growth. The compost (test treatment) was applied in spring of 2019 and again in the spring of 2020. At this site, plant cell density (PCD) was considered a potential covariate for pruning weights.

Comparison of moving window averages for winter pruning weights in 2020 revealed significant variation along the trial strips (Figure 4.2.1a); however, this assessment was likely conducted too soon after the compost applications. Trial assessment methods were reviewed and adapted for the winter of 2021. In 2021, a subset of sample vines with different levels of PCD were used to determine the linear relationship between pruning weights and PCD values. The linear regression model was then used to estimate the pruning weights for other vines, including missing vines in the trial strips. Use of PCD to estimate pruning weight 'smoothed' the graph of moving window averages for ease-of-interpretation (Figure 4.2.1b).

The trial results revealed that the pruning weights of vines treated with compost were numerically lower than those of non-treated vines at most locations in the strip – a result that was perceived by the producer to be counterintuitive. Adding elevation to the graph of moving window averages (Figure 4.2.1b) highlighted dips in elevation that were visible when walking down the rows. The trial results confirmed that pruning weights were generally higher at lower elevations. In short, the use of spatial data for elevation and PCD aided the presentation of clear results and interpretation of varying crop responses. The producer noted that: "*one would like to think that, that [improved understanding] would lead to improvements in management more broadly or just understanding a block better, which, invariably, you would have to say leads to improvements, be they efficiency, quality or whatever they may be*".

This trial required accurate overlays of different types of spatial data which was achieved through use of a block boundary survey and geo-referencing of target vines. The producer who conducted the compost trial has a relatively high degree of technical competence yet noted some difficulties of associated with this method: "*you've got to firstly purchase …a GPS of the correct accuracy…. Then will the GPS work on the day, to the accuracy you require……it doesn't always work*". These observations by the producer highlight a barrier to the use of PV tools and the opportunity for alternative technologies and/or access to appropriate services.

[17] Song, X. (2022) On-farm experimentation in the Australian winegrape sector: approaches and opportunities for change. Hobart, Tasmania: University of Tasmania, pp. 210.

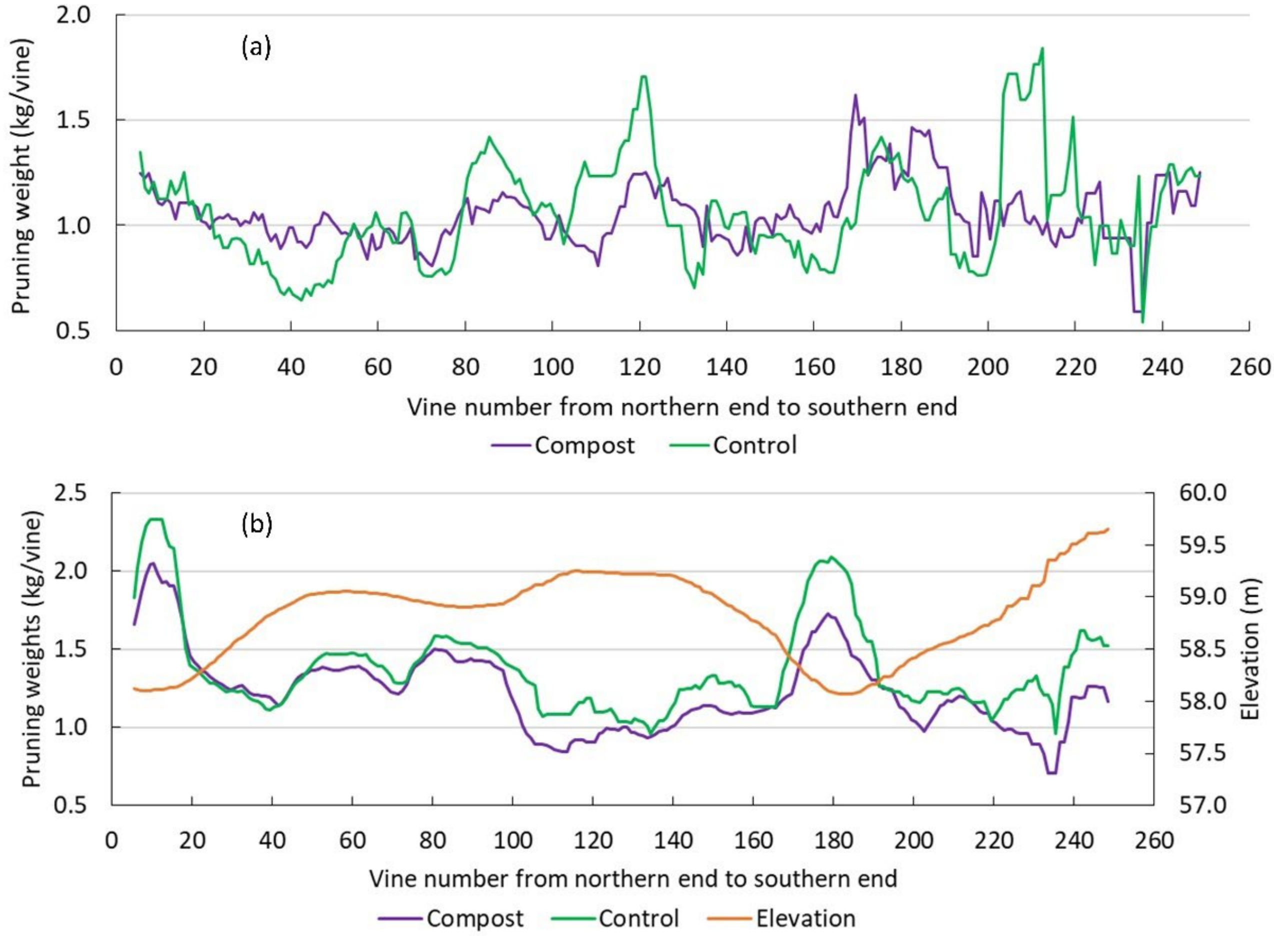


Figure 4.2.1 Spatial variation in pruning weights (kg/vine) for compost treated (test treatment) and non-treated (current practice) rows in (a) winter 2020 and (b) winter 2021 for strip trial positioned with a 5.2 ha block of Cabernet Sauvignon at Coonawarra, South Australia (Song, 2022)[18]. Compost was applied in the spring of 2019 and again in the spring of 2020. The pruning weights in 2021 were estimated using values of plant cell density, hence the smoothing effect of the moving window averages. Values of elevation (m above sea level) were sourced from a digital elevation model.

4.2.2 Case study 2 – vine mid-row management trial

This case study is not a producer-led trial; however, it illustrates the use of spatial data to interpret results from a strip trial.

The original trial for this case study was conducted across the entire area of a vineyard block by a team of CSIRO researchers (Panten *et al.* 2010)[19]. Their spatial data, sourced from a crop yield monitor and remotely-sensed imagery, were later used by Song *et al.* (2023)[20] to simulate a strip trial.

The trial involved a comparison of three mid-row management treatments (Figure 4.2.2) for their effect on yield (kg/m). Plant cell density (PCD) was a covariate to yield. The trial results show that once PCD exceeded about 1.4, then the yield of treatment CL (cereal or legume in alternating mid rows) was higher than that of treatment RM (ryegrass supplemented by mulch), and that treatment RM had a higher yield than that of treatment RC (ryegrass supplemented by compost). However, there was little difference in yield between treatments RM and RC at other locations in the trial strip. These insights would likely not have eventuated without the collection and analysis of yield and PCD at a sufficiently high degree of spatial resolution.

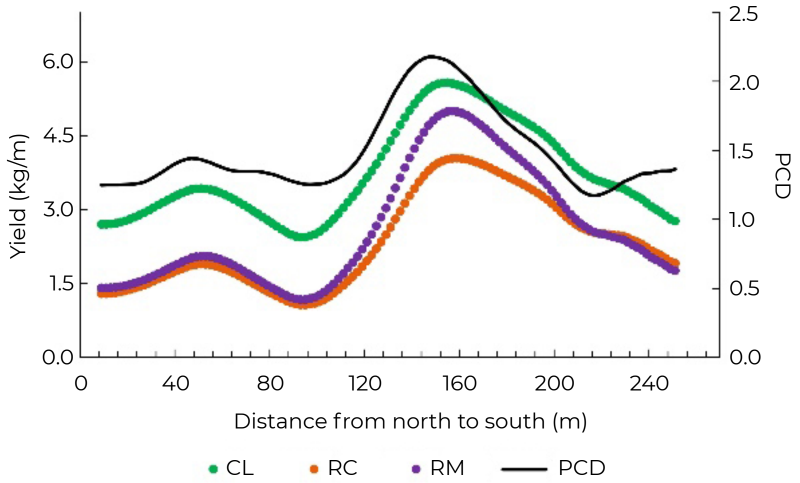


Figure 4.2.2 Results of trial strips to compare three mid-row management treatments (Song *et al.* 2023 sourced data from Panten *et al.* 2010). RC is ryegrass supplemented by compost (red line), RM is ryegrass supplemented by mulch (purple line) and CL is cereal or legume in alternating mid-rows (green line). The black line is plant cell density (PCD). Each window for the calculation of a moving window average was 10 sample points representing 20 m of row. Refer to Song *et al.* 2023 for the meaning of RBVI.

[19] Panten, K., Bramley, R. G. V., Lark, R. M. and Bishop, T. F. A. (2010) Enhancing the value of field experimentation through whole-of-block designs. *Precision Agriculture,* **11,** 198-213.

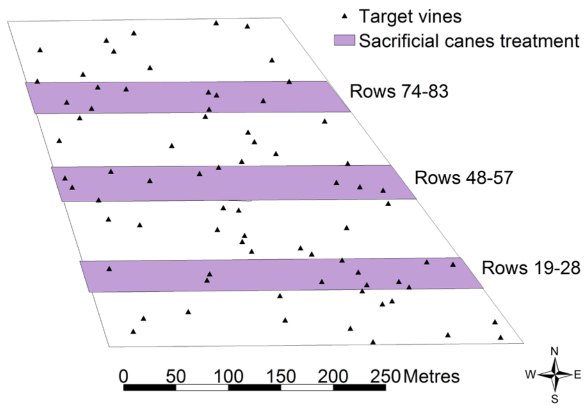
[20] Song, X., Bramley, R. G. V. and Evans, K. J. (2023) A method to position a simple strip trial to improve trial efficiency and maximise the value of vineyard variability for decision-making. *OENO One,* **57,** 97-107.

4.2.3 Case study 3 – sacrificial canes experiment

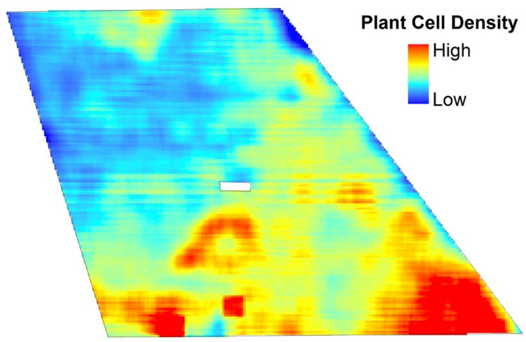
The trial for this case study was conducted by a commercial wine business without use of ancillary spatial data in the design or analysis of results. Data from the same experiment were also analysed by CSIRO researchers[21] who applied a spatial lens to data analysis and interpretation. The findings offer a precautionary tale of the situation when the underlying variability in land in a vineyard block contributes to effects on yield or fruit attributes that are greater than the effect of a test treatment.

The instructive example is a sacrificial canes experiment in 10.2 ha of Shiraz at Padthaway in South Australia. The trial involved three test strips, each of ten rows, in which sacrificial canes were retained during pruning (test treatment, labelled SC) and the remainder of the block was pruned conventionally (current practice, labelled C) (Figure 4.2.3a). The sampled vines were divided between the SC and C rows in approximate proportion to the area covered (Figure 4.2.3a). Statistical methods were used to separate the average effect of the test treatment from current practice (SC versus C in Table 4.2.3). The CSIRO researchers also explored the effect of inherent vineyard variability by identifying vigour zones using *k*-means clustering of plant cell density (PCD) (Figures 4.2.3b and c). These spatial data allowed comparison of crop responses in the different vigour zones (L versus H in Table 4.2.3).

a.



b.



c.

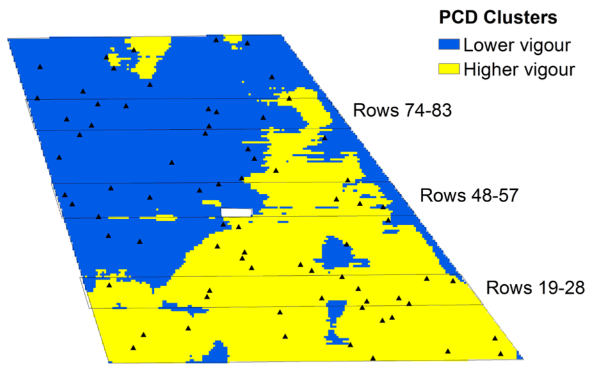


Figure 4.2.3 Adapted, with permission, from Bramley *et al.* (2005), Figure 2. The experiment was conducted by a commercial wine business in 10.2 ha of Shiraz at Padthaway, South Australia. Sacrificial canes were retained at pruning in 2003 in 3 strips, each of ten rows wide (a) 75 target vines were distributed between these and the remainder of the block (control). *K*-means clustering of a plant cell density (PCD = IR/R) image obtained at veraison 2001 (b) was used to identify vigour zones (c) to facilitate analysis of the effects of the sacrificial cane treatment. Image quality reflects the available technology at the time of the experiment.

[21] Bramley, R. G. V., Lanyon, D. M. and Panten, K. (2005) Whole-of-vineyard experimentation - An improved basis for knowledge generation and decision making. In: *Precision Agriculture '05.* Wageningen Academic, pp. 881-890.

Table 4.2.3 Differences between the test treatment (SC = sacrificial canes, n = 30) and current practice (C, n = 45) or zones categorised as low vigour (L, n = 37) or high vigour (H, n = 38) according to the values of plant cell density. The asterix (*) indicates that the vigour effect (L vs H) was greater than the treatment effect (SC vs C). Adapted, with permission, from Bramley *et al.* (2005).

Differences in the averages of each variable investigated										
	Yield (kg per m)	Bunch number	Bunch weight (g)	Berry weight (g)	Berries per bunch	Baumé (°Bé)	pH	Titratable acidity (g per L)	Colour (mg per g)	Phenolics (a.u per g)
SC vs C	-1.64	+0.5	-32.5	-0.06	-24	0	-0.08	+0.19	+0.01	+0.01
L vs H	-2.76	-5.6	-30.0	-0.21	-8	+0.8	+0.02	-0.25	+0.33	+0.19
	*	*		*		*			*	*

The results revealed significant differences between low and high PCD zones for yield and fruit attributes measured, except juice pH. Moreover, inherent vigour had more influence on specific attributes of fruit composition than the retention of sacrificial canes (Table 4.2.3). The CSIRO authors suggested that specific viticultural practices to control vine vigour would likely promote better management of fruit quality than use of sacrificial canes.

This case study is instructive because it highlights the value of considering the effect of inherent land variability in the design and analysis of experiments. If the effect of this underlying variation on the crop's response is not recognised or understood, then a decision to change viticultural practice may not be the right one if the difference in response between the test treatment and current practice is useful but **less** than the effect of features of the land such as changes in soil type or the impact of the land variability on vine vigour.

Panten and Bramley (2012)[22] observed a similar phenomenon during analysis of a whole-of-block experiment in Shiraz vines to compare the effect of spur pruning to 35 buds and shoot thinning during the growing season (10–12 shoots per m prior to fruit set) to pruning to 45-50 buds per vine (current practice). Like the Padthaway experiment, the effect of inherent vine vigour – a feature of the land – was greater than the treatment effect.

4.3 Conclusion

Adoption of the tools or precision viticulture during trials ultimately depends on the value they provide to the trial process (efficiency, effectiveness), interpretation of results (deeper insights) and the impact of the trial results on business decision-making (return on investment). Whether trials that use spatial data result in precision viticulture remains open to question. Use of PV tools, at minimum, will reveal spatially variable crop responses that in turn raise awareness of viticultural opportunities. These opportunities include spatially variable adjustments to viticultural practices to produce more grapes with desired attributes, changes to vineyard floor management in specific locations or altering the vegetation in targeted areas adjacent to the vineyard block. Effective experimentation ultimately reveals the things for which we had no previous awareness and guides us towards action with a higher degree of confidence in the process and the outcome.

22 Panten, K. and Bramley, R. G. V. (2012) Whole-of-block experimentation for evaluating a change to canopy management intended to enhance wine quality. *Australian Journal of Grape and Wine Research,* **18,** 147-157.

Afterword

By now you may be overwhelmed with the detail and/or nuances involved in planning and conducting an in-vineyard trial successfully. This in-depth treatment is intentional because once the detail is understood then running the trial should be relatively straightforward. Indeed, it was our goal to develop the simplest trial method that would also deliver confidence in the results.

Your first trial may take some mental effort and organisation; however, subsequent trials become easier as you embed the principles in your practice. As trials start to deliver value to the business, then routines and budgets can be developed to make them business-as-usual rather than additions to an already large workload. The methods can also be adapted readily for data capture by remote and on-the-go sensing.

No doubt your own trials will present challenges not covered here. Solving trial- and site-specific issues is precisely what will make your own trial uniquely relevant to your production context and goals. There is nothing like pouring over a set of interesting and robust trial results that, in turn, stimulate important discussions with relevant others. Trial results serve as great objects around which to extend conversations to matters that are crucial to doing your job well and with as little pain as possible.

The real power of in-vineyard trials is seen when groups of producers in a locality or region come together to share trial results. Insights can be multiplied, especially when all have a common trial language, and the results are easy to understand. The conversations that follow are likely to be broad and free flowing. In the words of an experienced viticulturist from Tasmania: "*We all want to learn, and it is easier to learn when we are all together*".

I encourage researchers to get involved in producer-led trials to learn what really goes on in vineyards and why. Expect a few 'light bulb' moments and learn to let go of power and control during experimentation. Embrace other forms of knowledge and know-how because these will be essential to developing practical solutions. Producer-led trials can inform the research questions that matter and who you involve in research for better outcomes.

Change takes time and effort. Yet, doing the same thing viticulturally and expecting different results is also someone's definition of insanity. Effective trials can build confidence in decisions that were once made by trying things and reaching a conclusion without a solid basis for change.

Happy trialling!

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