CASE STUDY: THE ADOPTION OF ROOTSTOCKS

Using the 'Market, Message and Means of Communication' framework to design an extension strategy.



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EXECUTIVE SUMMARY

This report details the design of an evidence based extension strategy, using the 'Market, message and means of communication' framework. Use of this framework involved working systematically through a series of questions which guided data collection and analysis to enable the identification of the market and target audiences for an innovation, the key messages these target audiences will be interested in and the best means of communicating these messages. These are then used to underpin the extension strategy.

The framework was identified and comprehensive data collected on the adoption of innovations in the wine industry through a Wine Australia funded research project entitled "Adoption of grape and wine R&D outputs. Who, what and why?" undertaken by Hill *et al.* (2015). This current work is an extension of that project and tests the 'Market, message and means of communication' framework on two case study innovations. This report details the first case study, which is on the adoption of rootstocks by grapegrowers.

Data was collected through interviews with selected grapegrowers, winemakers, nursery managers and industry experts, as well as an online survey completed by 143 grapegrowers.

The research identified that the primary market segment for the adoption of rootstocks is those grapegrowers who are expanding their vineyards through new plantings, or replanting existing vineyard area.

The key drivers for using rootstocks (why they were perceived to be useful) were found to be:

- Being in a phylloxera-infested region
- Planting on sandy soils with a known or suspected nematode infestation
- As a risk management strategy (e.g. if grapegrowers perceive there is a significant risk of future infestation or climate change)
- To address site-related such as saline or waterlogged soils, low water availability or vigour issues (including addressing low or excess scion vigour).

If none of these conditions are met, grapegrowers are highly unlikely to adopt rootstocks.

The key barriers (relates to the 'ease of use' concept) to the adoption of rootstocks were found to be their cost, which is significantly higher than ungrafted vines, and the risk of vine underperformance due to wrong rootstock choice for site.

Working through the framework enabled the identification of:

- Market segments and target audiences
- Relevant messages
- Sources of information used and likely to be used

The following target audiences were identified and extension strategies designed for:

- Growers planting or replanting vineyards with site-related issues
- Growers planting or replanting vines in infested vineyards
- Grapegrowers not currently planting or replanting vines
- Nursery managers, consultants and industry advisors
- Grower liaison officers and winemakers
- Regional associations.

Additional recommendations made were:

- Support regional rootstock trials where possible as risk of vine underperformance due to wrong rootstock choice for site was identified as a major barrier to rootstock performance. Where possible it would be useful to run these in conjunction with regional associations who can help disseminate trial information.
- Update generic information on rootstocks available to growers – particularly online and particularly related to the value proposition – ie the costs compared with benefits of using rootstocks instead of own-rooted vines.

The 'market, message, means of communication' framework was found to be a logical tool to use to guide data collection, analysis and the design of an extension strategy for adoption of rootstocks.

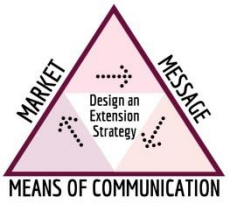
INTRODUCTION

In order to increase the effectiveness of extension efforts in the wine industry, Wine Australia invested in a project to identify the drivers for adoption of technology and innovation among grapegrowers and winemakers (Hill *et al.* 2015). The report proposed a methodology for developing an extension strategy based on the research findings, incorporated into the 'market, message, means of communication' (MMM) framework (Huffer 2012) as an organising mechanism.

The report's authors contend that use of the MMM framework enables the extensionist to focus in on the more important aspects of rootstock adoption, enabling an effective extension strategy to be developed. In this report the MMM framework is applied to the topic of the adoption of rootstocks in the Australian wine industry.

THE APPROACH

In this case study the application of the 'market, message, means of communication' (MMM) framework proposed by Hill *et al.* (2015) has been used to design an extension strategy by:



1. identifying the potential market segments and target audiences for and innovation
2. identifying the key drivers and barriers to adoption, and the key messages that related to these drivers and barriers
3. suggesting the best means of communicating these messages to the target market and audiences
4. using these findings to underpin an extension strategy

The MMM framework describes the need to:

- Identify and describe the technology, innovation or desired behaviour change under consideration.
- Identify and describe the potential market and target audiences. A 'market' is the population of actual and potential adopters of rootstocks. A market can be identified and divided up (segmented) based on common features. From these market segments, target audiences for extension initiatives have been identified.
- Identify drivers and barriers to adoption. People adopt or purchase something if they perceive there will be a net benefit. Understanding the needs of the market segments and the benefits they might seek, as well as the costs or barriers to adoption, enables target audiences to be selected and effective messages to be identified.

- Select the most effective means, or package of communication tools to convey the relevant messages to the target audiences.

There is additional information on this framework in the '*Adoption of grape and wine R&D outputs. Who, what and why*' project report (Hill *et al.* 2015).

Table 1 details the questions developed as part of this project. Answering the questions forms the basis for the extension strategy.

Table 1: The 'market, message and means of communication' framework key questions.

Q	Relevant concept	Key question	Clarification or examples
1		What is the technology, product or practice change ('the innovation') being considered?	Consider one discrete innovation at a time, otherwise it will become complex and confusing. Map the adoption sub-processes
2	**Market**	Who is the innovation relevant to? Is its adoption likely to be influenced by business outlook?	Who has adopted and is likely to adopt the innovation? Is it capital intensive to purchase? Will it provide short, medium or long term benefits?
3	**Market**	Is it only relevant to vineyards or wineries of a certain scale or with specific biophysical characteristics?	Will adoption provide benefits to small, medium, large or all scale vineyards or wineries? Or cool, warm or hot regions? Are there certain features of the business that make the innovation more or less relevant? For example grapegrowers with unirrigated vineyards are unlikely to use soil moisture monitoring.
4	**Market/ message**	Why would people find or potentially find the innovation useful? What are the drivers of adoption or the benefits that might be obtained?	What are the benefits being sought? What are the key questions someone would ask to ascertain if the innovation would be useful to them? Key drivers of adoption that have been identified are: quality, saving input costs, workplace safety, managerial flexibility etc.

5	**Market/ message**	What are the barriers to and costs of adoption?	Costs can be in terms of: • Financial cost • Risk of underperformance/ lost opportunity cost • Ease of installation, set up and on-going use • Need to obtain or develop new skills or knowledge • Time • Fear of change Are there barriers in the sub-process required for adoption e.g. availability of product?
6	**Means of communication**	Is the decision to adopt high or low involvement? Where is information sought?	For high involvement decisions, people generally collect information from a range of sources including their personal network, web, experts, retail and experiential information (they trial or go and look). Low involvement decisions are quicker with few if any sources of information used. Identifying where people seek information may highlight key 'influencers', potential audiences to use or spread information (e.g. retailers or consultants)
7	**Means of communication**	Who are the target audiences?	These will be market segments and/or key influencers or providers of information for those segments.

To adequately answer the framework questions, information needs to be gathered from a range of sources such as:

- the researcher's or extension provider's own knowledge and experience
- interviews with topic experts (by phone and in person)
- interviews with grapegrowers and winemakers
- web-based written resources
- industry publications

Data is collected until it is considered that sufficient information has been obtained to adequately answer the questions and hence develop the extension strategy.

CASE STUDY: ROOTSTOCKS

In this paper the MMM framework is applied to the adoption of rootstocks. For the collection of data, 20 interviews were conducted over the phone between July and November 2015with nursery managers, industry experts, grapegrowers and winemakers. A small survey was then designed and distributed using Survey Monkey. This survey was completed by 143 grapegrowers out of a distribution list of 679, representing a 21% response rate.

Background

What are rootstocks?

Rootstocks are used by grapegrowers as a component of grafted vines. Grafted vines consist of an aerial component which is the desired fruiting variety (scion – mostly *Vitis vinifera*) and a root system (rootstock) derived from usually non-vinifera grapevines which are better adapted to a range of soil conditions. The main grapevine rootstocks currently used by the Australian wine industry are from native American Vitis species. These species [*Vitis riparia, Vitis berlandieri* (also known as *V. cinerea* var. *helleri*), *Vitis champini (*and many others) evolved under a range of environmental conditions, enabling them to tolerate pests (e.g. phylloxera and nematodes) or adverse conditions (e.g. saline soils, water stress) better than the European *Vitis vinifera* vines (Cox 2015). The alternative to using grafted vines is to use self-rooted *V. vinifera* (own-roots).

There are around 75 grapevine rootstocks potentially available in Australia (although not all are readily commercially available), with three new rootstocks released by the CSIRO in 2012 and further breeding and trials ongoing.

Brief history

Rootstocks were not available when phylloxera was identified in Australia in 1877 and the removal of vines to eradicate phylloxera was practised up to the late 1890s. With the failure of vine removal to stop the spread of phylloxera, rootstocks began to be used in the early 1900s. However, although almost all vineyards in Europe and other grape growing countries of the world are planted on resistant rootstocks, where phylloxera is widespread, Australia has never adopted them widely except in the regions where phylloxera is present or close by.

Importance to industry

There are a number of benefits associated with planting on rootstocks. First among these is protection against phylloxera. Phylloxera is regarded as the world's worst grapevine pest as it has devastated

vineyards across almost all grape-producing countries including small areas of Australia. The only effective long-term management strategy for controlling phylloxera is a replanting program using vines grafted on to phylloxera tolerant rootstocks (Vinehealth Australia website). The same rootstocks are generally associated with tolerance to nematodes and crown gall, which are present in many vineyard regions in Australia, particularly in sandy soils and areas previously planted to grapevines or other horticultural crops.

Aside from protection from pests, rootstocks are potentially able to confer other viticultural benefits including drought tolerance, increased or reduced vigour, salt tolerance and reduced potassium uptake. They may also advance or delay maturity and affect fruit set.

From an industry perspective it is therefore considered advantageous that new plantings and replacement grapevines use vines grafted onto rootstocks to protect vineyards in case phylloxera spreads further, to mitigate the effects of climate change and to increase productivity (Whiting 2012). Martin (2014) estimated the net benefit of rootstock adoption (compared with own roots and assuming current rates of adoption) at $201m over a 2007-2040 timeframe (in 2014 dollars). To this end, Industry, State and Federal governments and Wine Australia have invested over $18 million in rootstock-related R&D between 2000-2012 (Martin 2014). This investment has been largely spent breeding, identifying, trialling and evaluating rootstocks under Australian conditions (Martin 2014).

Current adoption rates

The most recent national planting statistics for the Australian wine industry come from the 2014-2015 season (ABS 2015). New plantings of grapevines across Australia in 2014-15 were 1234 ha or just under 1% of the total planted area (135,177 ha). Assuming an average planting density of 1,600-2,000 vines per hectare, the new plantings equate to approximately 2 million to 2.5 million vines.

Information on the commercial plantings of grafted vines is variable between states and regions, with little quantitative data available on a national basis. The most accurate information is available for South Australia, where it is compulsory to report all plantings to Vinehealth Australia (formerly the Phylloxera and Grape Industry Board of South Australia). In South Australia, the total proportion of vines planted on rootstocks is 21%, while the proportion of new plantings (between 2012 and 2014) on rootstocks is 39% (data supplied by Vinehealth Australia, October 2015).

A summary of rootstock use in South Australian regions (Table 2) shows that there is considerable variation between the regions in their use of rootstocks. As the whole of South Australia is phylloxera

free, the variation must be attributable to regional differences in site-related factors such as soil type, water and climate.

Table 2: South Australian regional rootstock use (Vinehealth Australia 2015).

Region	Total % of plantings on rootstocks	New plantings (2014) on rootstocks
Adelaide Hills	5%	8%
Barossa Valley	24%	40%
Clare Valley	5%	12%
Coonawarra	6%	31%
McLaren Vale	10%	23%
Riverland	45%	78%
Total (SA)	21%	39%

In the Murray Darling and Swan Hill regions 67% of plantings are estimated to be on rootstocks (Sunrise nursery, pers. comm. 2015), while in Western Australia and Tasmania it is estimated that less than 5% of new plantings are on rootstocks (Colin Bell, pers. comm. 2015).

The problem

Although the statistics are incomplete, the indications are clear that the majority of grapegrowers are not planting on grafted vines.

Modelling undertaken by Martin (2014) indicates that there is a net benefit of planting on rootstocks in most situations, provided the optimum rootstock is chosen. Wine Australia would like to see an increased adoption of vines planted on rootstocks in order to maximise the value of investment in R&D and the transfer of benefits to industry in a highly competitive global marketplace where efficiency gains are essential to sustainability.

This paper works through the development of an extension strategy using the *Market, message and means of communication framework* as described above.

Defining the innovation

Q1. What is the innovation?

Adoption of rootstocks means making the decision to plant a vine where the fruiting variety (eg Shiraz, Chardonnay) has been grafted onto another plant – the rootstock variety (see Background).

In making that decision, a grapegrower is choosing between grafted vines and three main alternatives:

- Buying a dormant "rootling" from a nursery that has been grown in a field for 12 months after being started from a cutting (cane) or buying a "green pot" – a plant that has been grown in a pot in a greenhouse for a few months after the cutting was taken and callused
- Planting a callused cutting directly into the soil – which will eventually take root and grow
- Field grafting (top-working) buds onto an existing vine

Table 3 summarises the essential differences between these options. There are pros and cons with each, which makes the value proposition difficult to work out. In summary, planting cuttings, particularly those taken from another vineyard potentially at no cost, is the cheapest option but has the lowest survival rate. Planting grafted vines is the most expensive but may produce a crop sooner and minimise the long-term risks associated with vineyard soil issues, pest and disease issues and the health status of the plant itself (assuming it was purchased as certified health status material from a reputable nursery).

Table 3: Comparison between main vine purchasing options

Option	Cost per plant	Lead time*	Time to full crop	Relative failure rate	Potential issues
Top-working	$2	None	2 years	High	Compatibility and health issues, management
Cuttings	$1.50	None	4 years	Very high	Viability of cuttings
Rootlings (own-roots)	$2	12 months	4 years	Low	Minimal
Graftlings (rootstocks)	$5.50	12 months	3 years	Low	Possible compatibility issues (although minimal from a good nursery)
Green pots	+0.20	4-5 months	3 years	Moderate	Management, viability

*Lead time is based on a decision being made to plant in April/May of the base year. If the decision is made after pruning season, then all options have an additional delay until the next pruning season when cuttings can be taken.

Cost modelling done by Newson, Ratcliff and Freckleton (2012) indicates that despite the additional planting costs, planting on grafted vines produces a better return on investment over five years than

planting with own-rooted rootlings (because of the earlier crop). However, top-working is better than either of these options using that measure.

The market

Q2. Is the adoption of rootstocks likely to be influenced by business outlook?

As noted above, the rate of new planting or replanting in 2014-15 was 1%. As the wine industry has been in a down-cycle for some years and the total planted area has been stagnant or declining, it is reasonable to use a figure of 1% as a rough estimate of the annual demand for new vines (equating to 2-2.5 million new plants per year). This constitutes the maximum potential size of the market for rootstocks (grafted vines). In the medium term this market size may increase as existing vines planted during the boom from the mid-1990s to the mid-2000s start to decline in productivity, and/or consumer demand changes more rapidly (Whiting 2012).

New planting vs replanting

Grapegrowers use rootstocks when either:

- Planting new vineyards or expanding existing vineyards.
- Replanting existing vineyard area – most commonly to change varieties but also due to pest or disease issues, or age-related loss of productivity (Whiting 2012).

New planting is likely to be undertaken by vineyard businesses with an 'expanding business outlook' as it represents a reasonably significant capital investment (in trellis and irrigation infrastructure) and requires an increase in total running costs for the property to maintain the new plants in addition to the existing area. This may also mean purchasing more land, employing more labour and/or purchasing additional machinery (depending on existing resources and scale of additional area). Hill *et al.* (2015) found that 13% of grapegrowers were in the "expanding" market segment; however, this does not necessarily equate to 13% of the vineyard area.

Replanting requires a lower capital investment and would not be expected to impose additional running costs on the vineyard once the vines are established. Therefore grapegrowers replanting are most likely to be in the 'steady business outlook' segment of the industry, although there is a significant cost associated with purchasing new plants (especially if grafted) and there is a loss of income while the new plants come into production that has to be considered as part of the investment.

Hence the maximum potential 'market' for rootstocks consists of grapegrowers expanding their vineyard size and production or staying steady but replanting vines. This estimation of market composition and size will be further refined through answering the rest of the questions.

Q3 Are rootstocks only relevant to vineyards of a certain scale or with specific characteristics?

Rootstocks are relevant to grapegrowers with any scale of vineyard. Theoretically rootstocks are also applicable to vineyards in all grapegrowing regions (although the choice of rootstock variety might be different) and on all soil types.

Market/message

This section examines the benefits and barriers of adoption, which enables refinement of the market for an innovation, and identification of the information and messages that will be sought.

Q4 Drivers of adoption (i.e. perceived usefulness or benefits)

How useful the grapegrower or winemaker perceived the innovation would be was identified was identified as the key factor, or the strongest driver of adoption (Hill *et al.* 2015). While the *reasons* a grapegrower or winemaker would perceive an innovation to be useful varied depending on the innovation under study, some common themes around increasing productivity emerged, specifically people sought to:

- Reduce input, including labour, costs
- Maintain or improve grape and/or wine quality or yield
- Increase workplace safety
- Increase managerial flexibility

Dry (2007) describes the main reasons for choosing rootstocks as:

1. Phylloxera tolerance
2. Nematode tolerance
3. Risk management
4. In response to site-related issues, e.g. salinity, water availability, vigour or varietal issues.

The reasons identified by interviewees for choosing rootstocks were consistent with this list, and reflect the themes identified by Hill *et al.* (2015) - ie an innovation being perceived as useful if it is seen to maintain or improve productivity.

A decision tree describing these key drivers and associated benefit segments is shown in Figure 1.

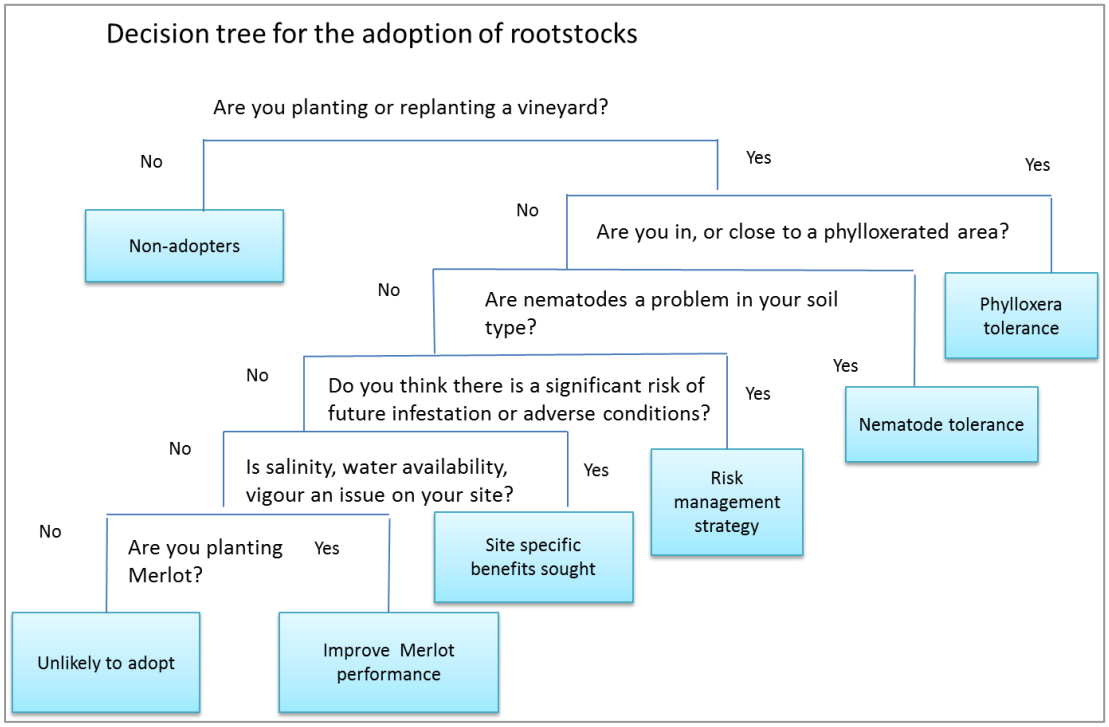


Figure 1: Decision tree on the adoption of rootstocks

Other potential benefits of rootstocks identified in the literature are to reduce fruit potassium intake, modify berry size, improve nutrient uptake, increase yields, change fruit ripening times and reduce lag time until production. These were not identified as significant drivers through the interviews conducted in this study.

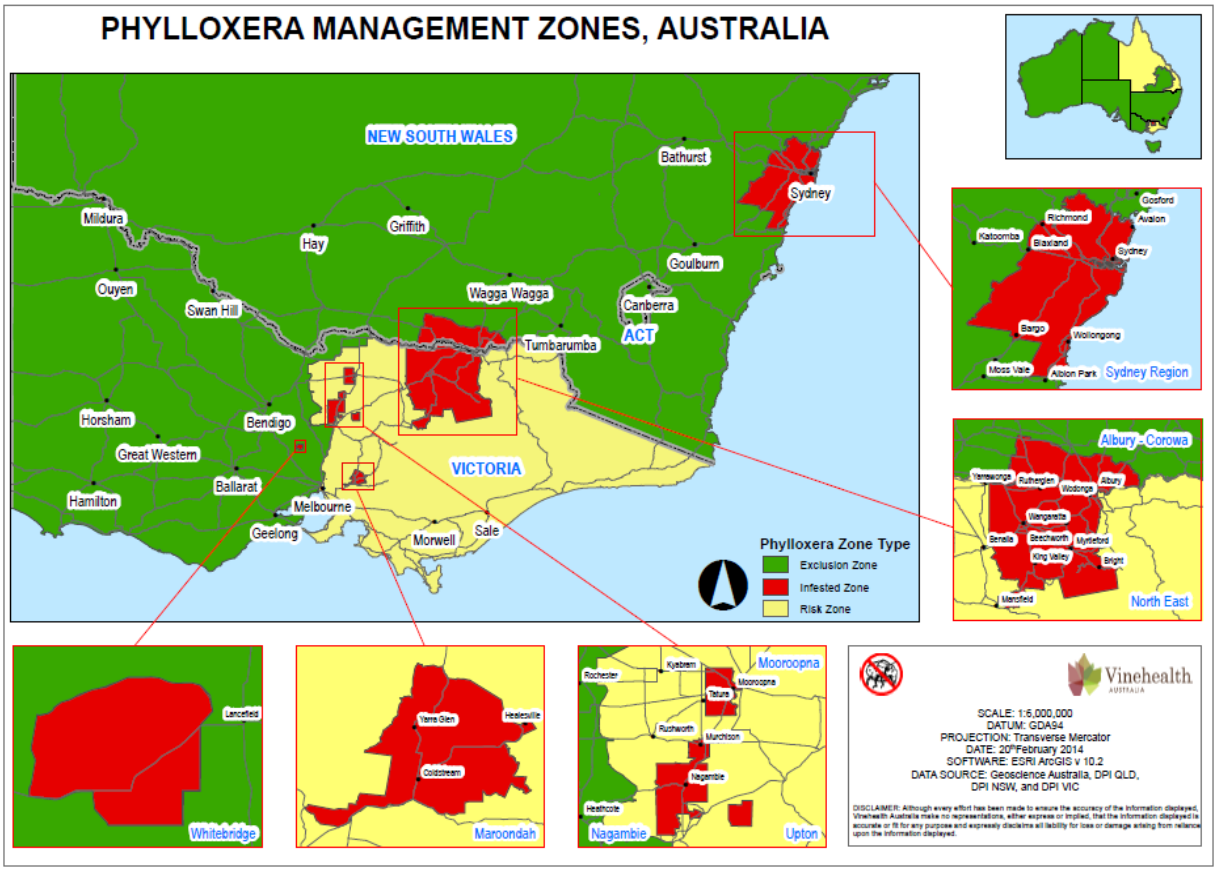
The main drivers are discussed in more detail below.

Planting rootstocks for Phylloxera tolerance

Interviews with grapegrowers in phylloxerated vineyards and industry experts indicate that it is extremely unlikely that anyone planting or replanting in a phylloxera-infested region (even if the vineyard itself is not currently infested) would not use a phylloxera tolerant rootstock. The spread of phylloxera is considered inevitable over short distances and own-rooted vines have little phylloxera tolerance, so if own-rooted vines were planted, they would not be productive or would die.

There are a number of phylloxerated regions in Victoria and one in New South Wales (see Figure 2). The most recent Phylloxera Infested Zone was established in Mansfield in 2010, and the Yarra Valley Zone has been expanded several times, the last in February 2014 (John Whiting 2015 pers. com).

Figure 2: Phylloxera distribution in Australia 2015. Source: Vinehealth Australia website.



Vinehealth Australia was very active in raising awareness and promoting planting on rootstocks between 1997 and 2008 but activity has declined in that area since then, coinciding with a decline in plantings and change in philosophy of the organisation. That, combined with the slow movement of phylloxera and its presence in only selected regions appears to have led to reduced concerns over the potential spread of phylloxera among grapegrowers in South Australia, Western Australia and Tasmania in particular. While the sample of grapegrowers interviewed was relatively small, many of them said that they did not perceive the risk of phylloxera infestation to be high for their vineyard, and hence it was not a strong driver for them to plant on rootstocks. One grapegrower in the Barossa Valley said: "We are concerned about phylloxera but we will wait to plant on rootstocks until it arrives". However the survey results indicate that other growers are more concerned about phylloxera spreading, as another grower said "Western Australia is phylloxera free and if does arrive we will be in deep trouble".

Planting rootstocks for nematode tolerance

Sandy soils, previously planted to grapevines or other horticultural crops, particularly citrus, are likely to build up nematode populations over time. Nematode infestation reduces the vigour and life span of own-rooted vines. Therefore in replant situations in sandy soils, planting on a tolerant rootstock is as

important as it is in a phylloxera infested soil. In general, most phylloxera-tolerant rootstocks are also nematode tolerant (although recent evidence has suggested that some rootstocks have insufficient tolerance to a particular race of root knot nematode) therefore a decision to plant on rootstocks for nematode tolerance will provide the additional benefit of insurance against phylloxera. Ironically, however, sandy soils (the most nematode-prone) are the least conducive to the establishment of phylloxera.

An interesting finding from the interviews was that, rather than conducting a soil test to determine the level and type of nematodes and therefore the need for rootstocks, it was more common to choose rootstocks "because nematodes were likely to be there", or to decide not to use rootstocks because "I'll just wait and see if I get a problem". The cost of the nematode testing was seen as a deterrent.

Planting rootstocks as a risk management strategy

A number of grapegrowers interviewed said that they were planting rootstocks as a risk management strategy. The key risks mentioned were: the potential for a phylloxera or nematode infestation, climate change and an increasing scarcity and cost of water.

On the flip side, a few grapegrowers said that changes in consumer varietal preferences posed more of a threat to a vineyard's long term sustainability than phylloxera or climate change. One grapegrower said that if he gets five years out of a block of vines before the winemaker requires them to be grafted over or replanted to a different variety he thinks he is doing well. Similarly, some respondents noted that Eutypa is a significant issue in some regions; this requires vines to be cut right back or replaced after 10-15 years, reducing the justification for investment in rootstocks.

Planting rootstocks to manage site-related issues

Rootstocks can be selected for superior tolerance to drought (low water availability), waterlogging and salinity, as well as to reduce or increase scion vigour or address specific varietal vigour issues – eg with Merlot. Some grapegrowers interviewed chose to plant on rootstocks seeking these benefits, which are very site dependent.

Martin (2014) argues that grapegrowers select and plant a particular rootstock seeking a key, or a few key benefits. Other benefits are considered a bonus or viewed as insignificant. This research found that the key benefits sought were dependent on the grapegrower's experience with and attitude to rootstocks, as

much as on the situation. For example, grapegrowers in this segment may be in the same region, on sites with similar issues yet have made completely different decisions regarding the use of rootstocks.

A benefit identified by some grapegrowers in the interviews, not previously described in the literature was the ability to reduce inputs by choosing a high vigour rootstock, hence reducing costs of production. This particularly applies to water (some rootstocks are reported to use 20% less water while producing comparable yield to non-grafted vines or other rootstocks) and fertiliser. Previously high vigour rootstocks have been considered to be suited to situations where high yield is required, or where poor soils mean that an own-rooted vine will not thrive. The current economic climate means that reducing the cost of growing the same yield is a significant benefit.

Snap shot of survey results

49% of the survey respondents had planted or replanted vines in the last five years

Of these, 68% **HAD** adopted (planted) rootstocks. The **MAIN** reason given for adopting rootstocks was:

- As a risk management strategy (34%)
- To influence scion vigour (19.2%)
- As a trial (10.6%)
- The vineyard is in a phylloxera zone (10.6%)
- The vineyard is nematode infested (8.5%)
- To manage site related issues (8.5%)
- Other reasons (8.5%)

Summary

Figure 1 shows that the key benefit sought by grapegrowers depends on their situation. Almost all the grapegrowers interviewed with phylloxera or nematode-infested sites choose to plant on rootstocks. Rootstocks were also planted as a risk management strategy, and sometimes if the site had issues (i.e. salinity, low water availability). If none of these criteria were met, the grapegrower was unlikely to use rootstocks.

Q5 What are the barriers to, and costs of adoption of rootstocks?

Hill *et al.* (2015) found that 'perceived ease of use' or how easy an innovation is to adopt and use is a factor grapegrowers and winemakers consider when determining the 'perceived usefulness' or how attractive an innovation will be to adopt. Dimensions of 'perceived ease of use' not only include the cost of the innovation, but how much mental effort, time and learning is required to adopt and successfully

use the innovation. Working through the adoption processes and the sub-processes provides a systematic approach to identify these costs and barriers. The main barriers identified for rootstocks are summarised in tables 4 and 5 and discussed in detail below each table.

Table 4: Costs and barriers to adopting rootstocks

Costs of adopting rootstocks	Potential barrier
Financial	Rootstocks 'not perceived as useful' and hence not worth the additional cost compared with non-grafted vines
Risk of underperformance/ lost opportunity cost	Risk of underperformance due to wrong choice of rootstock as a result of lack of local information on specific rootstock/ scion performance Perception of lower wine quality from rootstock fruit Grafting potentially mixes biotic organisms (virus, fungi) that are innocuous on their own but produce problems when combined. The grafting process in a nursery potentially introduces unwanted diseases

Rootstocks 'not perceived as useful' and hence not worth the cost

The main barrier identified through the interviews was that, to many grapegrowers, rootstocks are not perceived to be necessary, and hence not worth the additional cost. The grapegrowers interviewed with vineyards distant from existing phylloxera infestations, and without nematode pressure, water quality (including salinity) or water availability issues, and not attempting to grow high-yielding crops, did not perceive rootstocks to be useful to them. The benefits of using rootstocks in situations where there is no pest or other pressure that would lead to the vine not thriving, are usually not evident because own-rooted vines perform as well as grafted vines. The scarcity of regional trials (see below) means that there is not always relevant local information that can be applied to enable grafted and non-grafted vines to be directly compared in the same situation at the same time. The benefit in terms of protecting against a possible future infestation of phylloxera is only possible to quantify in terms of a grower's aversion to risk.

Risk of vine underperformance due to wrong choice of rootstock for site

There was widespread agreement that sufficient generic information was readily available about rootstock selection. However many of the grapegrowers interviewed said that there was a lack of site-specific or region-specific information, such as regional rootstocks trials. The grapegrowers said that not being able to see rootstocks, and talk to an experienced grapegrower growing rootstocks in their region, or on a site with similar biophysical conditions or wine styles, made them feel that planting on rootstocks in a 'new' site was a risk, and that they also found it difficult to identify which rootstocks-scion

combination would perform best. A number of the grapegrowers interviewed said they found selecting the right rootstocks and varieties for their sites difficult and confusing.

A powerful disincentive was found to be any anecdotal evidence of rootstock non-performance. For example, one grapegrower reported a neighbour's experience of planting grafted vines that never yielded commercial quantities of fruit, resulting in financial devastation for the grapegrower. Experiences like these can strongly influence the behaviour and opinions of other grapegrowers. In another example, it was reported that a particular rootstock might not have sufficient tolerance to root-knot nematodes, with the consequence that sales of that rootstock plummeted.

Perception of lower wine quality from rootstock fruit

Some of the grapegrowers and one of the industry experts interviewed commented that there is a belief that rootstocks lead to poorer quality wine, with the industry expert's suggestion that it was more of a management than a rootstock issue *per se*. This perception of inferior quality fruit from rootstocks was mainly from the warmer areas. In cool premium wine regions e.g. Yarra Valley it was suggested that grapegrowers were uncertain about the impacts of rootstock combination with the various clones in use, for that region. There was concern expressed also that nothing was known about how rootstock wine from that region would age over a 10-20 year period. This indicates that the problem is lack of region-specific information and risk of the unknown, rather than a legitimate concern based on evidence. It should be noted that most of the world's wine is produced from grafted vines and has been for more than a century. Also, highly regarded wines from the Rutherglen, Glenrowan and Nagambie areas have been grown on rootstock for over 100 years.

In 2001, the Phylloxera and Grape Industry Board of South Australia (now Vinehealth Australia) completed a rigorous study and found that winemakers and grapegrowers did not perceive rootstocks to have inevitable negative effects on quality. They could have either positive or negative effects depending on the situation and how the vines were managed (Hathaway 2001).

However, the comments from the interviews suggest that there may be a persistent myth that "other people" think rootstocks will reduce quality, although no-one when specifically questioned would admit to believing that. One interviewee in the current research noted that he had planted on Ramsay rootstock, despite "a prevailing view" that it was a bad choice, because a respected person in the industry had said that it was in fact okay, which reinforced his own belief that with the right management, this

would be the ideal stock to ensure the resilience of his vines in difficult and variable climatic conditions expected as a result of climate change.

Snap shot of survey results

The 32% of survey respondents that had planted or replanted vines in the last five years on ungrafted vines, said the **MAIN** reason they **DID NOT** plant on rootstocks was:

- There is a low risk of phylloxera coming to their region (30.4%)
- The cost of rootstocks (17.4%)
- Concern that the grafted vine would not perform as well as ungrafted (17.4%)
- They do not have nematodes or site related issues (17.3%)
- Concerns that winemakers would be less likely to buy the fruit (4.3%)
- Other reasons (13.2%)

Table 5: Adoption sub-process and potential barriers

Adoption sub-processes	Potential barriers to rootstock use	Comment
Selecting rootstocks	Difficult to get local or site specific information on how different rootstocks will perform	Found to be a barrier
Ordering and purchasing rootstocks	Lack of availability of preferred rootstock/scion combination	Found to be a minor barrier
Planting rootstocks	Incompatibility between rootstocks and clones Virus issues with combination of scion and rootstock	Raised by some interviewees but considered to be unlikely to occur with material bought from a reputable nursery.
Managing rootstocks	Managing grafted vines compared with ungrafted vines	No difference between grafted and ungrafted vines (although every new variety/planting requires adjustment to management).

Selecting, ordering and purchasing rootstocks

An examination of the adoption sub-processes indicates that the main point in the process where a potential barrier exists is at the point of selecting rootstocks, where it may be difficult to get local or site-specific information on how different rootstocks will perform. This has been discussed above.

Some of the grapegrowers interviewed said they had difficulty accessing their preferred rootstock/scion combination, with some rootstocks not being available in commercial quantities, and some nurseries potentially not having enough source material, particularly of new rootstock selections.

Disease and incompatibility issues

Rootstock diseases and incompatibility with scion material have been reported as an issue (Whiting 2012) particularly in planting material supplied when demand greatly exceeded supply and many different sources of propagating material were used. While some interviewees (JW, PC) reported that these issues have now been largely overcome with improved nursery practices and progress in testing and treating plant material, other interviewees reported variation in quality of plants supplied. None of the survey respondents listed rootstock- scion incompatibility as a major issue.

Managing rootstocks versus own rooted vines

Perceived difficulty in implementing, learning how to use or training others in the use of technologies has been identified as a barrier to adoption (Hill *et al.* 2015). However, in the case of rootstocks there were no indications that any of these barriers would apply. The interviews confirmed that grafted vines are no harder to manage than own-rooted vines, and that although managing any new vine would require an adjustment in management, this would be the case for a change to a different variety or clone, or even a new planting of the same variety, as much as it would to a grafted vine. Therefore there is no additional burden of adjustment (or disruption) in planting on rootstocks.

Summary

The key barrier to using rootstocks was found to be the perception that the additional cost of purchase was not warranted. Lack of confidence in how the various rootstocks will perform in different sites is an additional barrier.

Means of communication

Q6 Is the decision to adopt rootstocks high or low involvement? What information sources do grapegrowers use to find out about rootstocks?

When a decision is high involvement, i.e. important or risky, people generally collect information from a range of sources including their personal network, web, experts, retail and experiential information (they trial innovations or go and look at what others are doing). Low involvement decisions are quicker, with few if any sources of information used.

The selection and purchase of rootstocks would generally be considered to be a high involvement decision as it is an expensive, long-term purchase that is hard to reverse, with significant risk attached if it goes wrong. Therefore depending on their existing knowledge, it would be expected that grapegrowers would seek information from a range of sources – including written, interpersonal and experiential sources.

Information sources can be broadly classified into:

- Written information
- Interpersonal information
- Experiential information

The most widely available information sources for grapegrowers considering rootstocks were found to be:

1) Written information (published and internet-based)

The book 'Choosing rootstocks' by Nick Dry (2007) was mentioned by grapegrowers as a valued source of information. Frequently used on-line resources included the Vinehealth Australia website and the Yalumba rootstock selector (which is currently being updated), as well as some other nursery websites and information on a few industry associations' websites. Some nursery websites have information including a fact sheet prepared many years ago by Phil Nicholas on rootstock selection.

It should be noted that most of the available online information, with the exception of a specific fact sheet on the "new" CSIRO-bred rootstocks, and the Yalumba Rootstock Selector, is at least eight years old and has not been substantially updated in recent years.

The key questions asked by grapegrowers relating to the adoption of rootstocks are:

1. **What are the economic costs and benefits of using rootstocks versus own-rooted vines in a non-infested site?**
2. **Which rootstocks are best for my site?**

Tables 12 and 13 (Appendix 1) give a summary of the main sources of written information for answering each of these questions, which were looked at as part of this project.

2) Interpersonal information

Nursery managers

People were found to be a major source of information – mainly nursery managers who supplied the planting material. There was a consistent finding in the interviews with nursery managers that customers would come along with a fair idea of a) whether they wanted to use a rootstock or not and (if yes) then b) which one to choose. The role of the nursery manager was to confirm or fine-tune their selection. A number of grapegrowers said they had a preferred nursery that they always used when purchasing vines.

Researchers/ extension officers/ consultants

Other key sources of interpersonal information are researchers/extension officers/ consultants such as John Whiting and Peter Clingeleffer who are well-known in the industry.

Winemakers and grower liaison officers

Individual grower liaison officers employed by wineries (GLOs) and grapegrowers with 'hands on' rootstock experience were also often consulted. Grapegrowers sought advice from the winemaker or GLO regarding whether or not to plant on a rootstock, whereas the interviews suggested that by the time they contact the nursery, they have generally already made their mind up whether to plant on grafted or own-rooted vines.

3) Experiential information

A number of grapegrowers mentioned visiting vineyards to look at vines growing on rootstocks. It was particularly noticeable that in regions where there were no local rootstock trials and no "collective wisdom" in the region about rootstocks, it was unlikely that grapegrowers would choose to plant on rootstocks. Some regional grapegrower associations were found to be effective in supporting rootstock trials and disseminating information, making them another audience for rootstock related information.

Summary

Grapegrowers may spend considerable time and effort, and use a range of sources researching their rootstock selection decisions. Access to experts, regional trials and accurate data will reduce this search time and the risk of mis-purchase.

Q7 Who are the target audiences?

The target audience for the innovation has been described under "market". However, in order to reach the target audience it may be appropriate to go to indirect sources. It is known that grapegrowers value and seek out the opinions of people in a number of key groups. These groups can also be targeted with

extension messages in order to promote adoption among grapegrowers. Therefore the target groups for the extension strategy related to adoption of rootstocks are:

- Grapegrowers
- Industry advisors, nursery managers, consultants
- Winemakers and grower liaison officers
- Regional association representatives

Group 1: Grapegrowers

The primary target audience for the extension strategy is grapegrowers – as this is the group that will ultimately adopt the innovation (planting on grafted vines). As discussed above under "Market", the specific market segment that is planting at any given time is likely to a small percentage of the total industry. However, as noted above, it is likely that the requirement for new plantings will increase over the next ten years as vines age and consumer preferences change. Over the next ten year period, it is possible that up to 50% of the grapevines in Australia will be replaced.

Group 2: Industry advisors, nursery managers, consultants

As indicated above, this group is a very important source of information for grapegrowers seeking to fine-tune their rootstock selection. Most nursery managers indicated that they did not try to persuade grapegrowers to plant on grafted vines, but would provide information relating to the selection of a suitable rootstock if requested. Therefore this group could perhaps be given more information on the value proposition for grafted vines and encouraged to present it to grapegrowers.

Group 3: Winemakers and Grower Liaison Officers

This group is different in that grapegrowers will often look to advice from the winemaker or GLO regarding whether to plant on a rootstock, whereas by the time they go to the nursery, it seems that they have generally already made their mind up. The winery is in a strong position of influence as the potential buyer and therefore if they indicate a preference for own-rooted vines, this is likely to influence the grapegrower – and conversely, if they expressed an active preference for rootstocks, this would also be a strong potential influence. The winemaker/GLO would mainly interested in the effect of the rootstock on the grape and hence wine characteristics rather than the viticultural benefits that a rootstock could confer.

Group 4: Regional associations

Regional associations, particularly technical committees associated with these associations, have been found to be effective in supporting rootstock trials and disseminating information.

Designing an extension strategy

Working through the framework has enabled the identification of:

- Market segments and target audiences
- Relevant messages
- Sources of information used and likely to be used

The following target audiences have been identified and extension strategies designed for:

- Growers planting or replanting vineyards with site-related issues (Table 6)
- Growers planting or replanting vines in infested vineyards (Table 7)
- Grapegrowers not currently planting or replanting vines (Table 8)
- Nursery managers, consultants and industry advisors (Table 9)
- Grower liaison officers and winemakers (Table 10)
- Regional associations (Table 11).

Extension strategy 1: growers planting or replanting vineyards with site-related issues

Table 6: Extension strategy for grapegrowers planting or replanting in vineyards with site-related issues or considering planting rootstocks as a risk management strategy.

Target audience	Growers planting or replanting in vineyards with site-related issues or as a risk management strategy
Rationale	This group may adopt rootstocks if convinced of their value, and of confident of selecting a rootstock that will perform well in their site
Aim of extension	Awareness, attitude change and informed decision making
Target audience key questions	1. Are the benefits of planting rootstocks worth their additional purchase cost? 2. Which rootstock will best suit my needs and vineyard site?
Message	'Rootstocks vs own roots'- a guide describing and quantifying benefits under a range of physical conditions Evidence that rootstocks can ensure the long-term sustainability of vines in the context of future threats like the spread of phylloxera and climate change Information on which rootstocks are best suited to manage different issues (i.e. salinity, drought etc) and site characteristics (i.e. soil type, climate)
Suggested means of communication	Simple articles and advertising in industry magazines, industry forums to catch attention and signpost more complex (i.e. web based) information. Regional trials to enable grapegrowers and winemakers to see and evaluate how rootstocks will perform under local conditions, and to build capacity of local advocates (i.e. interested participating grapegrowers and regional associations) to disseminate locally relevant information. Inclusion of rootstock "angle" in workshops and forums where possible – e.g. whenever climate change, vigour, reducing input costs are discussed. Web based 'rootstocks vs own roots'- performance and financial data and research results. grapegrower testimonials to support the key messages. Web based 'rootstock selector' tools and advice. If possible supported with expert in-person support and verification – e.g. "ask the expert" perhaps operated by AWRI.
Location of audience	Salt or drought prone areas e.g. Langhorne Creek, Pathaway. Regions with reduced water availability. Areas with sandy soils e.g. Riverland, or near phylloxera zones.

If resources for extension are limited, this strategy is likely to have the most 'bang for buck' as this is the group likely to have a relatively low current rate of rootstock use but a high potential benefit.

Extension strategy 2: grapegrowers planting or replanting vines in infested vineyards

Table 7: Extension strategy for grapegrowers planting or replanting vines in infested vineyards

Target audience	Growers planting or replanting vines in infested vineyards
Rationale	These grapegrowers are the main group currently using rootstocks
Aim of extension	Support decision making and reduce risk of mis-selection of rootstock variety
Target audiences key questions	This group are already convinced of the need to plant on rootstocks. Their questions are in regard to which rootstocks will best suit their site and objectives
Message	The performance of the various rootstocks under a range of conditions
Suggested means of communication	Written Information to enable selection of best rootstock for individual sites- web based e.g. Yalumba rootstock selector. Supported with expert in-person support and verification – e.g. "ask the expert" perhaps operated by AWRI.
Location of audience	Phylloxerated areas e.g. Yarra Valley, Goulburn Valley etc. Nematode prone areas particularly the Riverland, Murray-Darling, Swan Hill

Extension strategy 3: grapegrowers not currently planting or replanting vines

Table 8: Extension strategy for grapegrowers not currently planting or replanting vines

Target audience	Growers not currently planting or replanting vines
Rationale	The majority of grapegrowers are in this group at this stage. They may plant or replant in future, in which case it is desirable they consider using rootstocks.
Aim of extension	Awareness
Target audience key questions	None
Message	That using rootstocks provides a range of benefits, can make good sense economically and should be considered if planting vines in future
Suggested means of communication	Simple, catchy messages. More detailed information will be ignored
Location of audience	All grape growing regions

Extension strategy 4: nursery managers, consultants and industry advisors

Table 9: Extension strategy for nursery managers, consultants and industry advisors

Target audience	Nursery managers, consultants and industry advisors
Rationale	These people have been identified as important sources of grower information
Aim of extension	To provide accurate, objective and comprehensive information
Target audiences key questions	Dependent on their roles
Message	What is current in rootstock research Where to find the latest information and research results
Suggested means of communication	These groups are geographically diverse, are influenced, and potentially constrained by their commercial interests, and already would have strong attitudes to rootstocks and use multiple sources of information. Therefore objective information such as comparative costs and trial results presented in written format eg online or in regular journal articles would be most efficient. Webinars could also be a possible strategy for providing up-to-date information including a comparative cost-benefit analysis.
Location of audience	All regions

Extension strategy 5: grower liaison officers and winemakers

Table 10: Extension strategy for grower liaison officers and winemakers

Target audience	Grower liaison officers and winemakers
Rationale	These people have been identified as sources of grapegrower information
Aim of extension	To test or dispel myths about reduced grape and wine quality from rootstocks To provide information on site-related benefits of rootstocks
Target audiences key questions	What is best for the wine?
Messages	In addition to the main benefits, there are additional benefits to using rootstocks such as reduced potassium uptake and manipulation of ripening times, which can make your grapes more attractive to a winemaker Correctly managed vines planted on rootstocks do not reduce the quality of the resultant wine – in fact they can enhance it.
Suggested means of communication	Articles in industry magazines presenting research results related to quality Wine tasting opportunities – eg from rootstock trial wines Presentations as part of industry technical conferences
Location of audience	Large corporate wineries that purchase fruit and advise multiple grapegrowers.

Extension strategy 6: regional associations

Table 11: Extension strategy for regional associations

Target audience	Regional associations
Rationale	Regional associations were found to support local trials and to be effective in supporting rootstock trials and disseminating information
Aim of extension	To encourage associations to access services and information to support and inform their grapegrowers
Target audiences key questions	How to access support to start local rootstock trials. Which rootstocks will perform best in their region
Message	That support is available and that rootstocks are/ will become important for most regions
Suggested means of communication	Personal presentations by experts at committee meetings Offer to support regional rootstock trials in the region – with participation by the committee in selection of the trial varieties, trial site etc and with ongoing management and data collection Support for committee members to visit trials conducted in regions with similar characteristics
Location of audience	Yarra Valley, Western Australia, Tasmania. Areas where rootstocks are not commonly used.

Additional recommendations

Recommendation 1

Support regional rootstock trials where possible as risk of vine underperformance due to wrong rootstock choice for site was identified as a major barrier to rootstock performance. Where possible it would be useful to run these in conjunction with regional associations who can help disseminate trial information.

Recommendation 2

Update generic information on rootstocks available to growers – particularly online and particularly related to the value proposition – ie the costs compared with benefits of using rootstocks instead of own-rooted vines.

A brief overview of information currently available to, and accessible by, grapegrowers and the gaps in this information is presented in Appendix 1.

CONCLUSIONS

The primary finding from this project was that even with a good existing working knowledge about rootstocks and the Australian wine industry, the application of the 'market, message, means of communication' framework was very helpful in designing the optimum extension strategy, as it meant that data was systematically collected and analysed, which that led to some of the authors' existing assumptions and beliefs relating to the adoption of rootstocks being challenged.

In addition, use of the framework acts as an organising mechanism to guide the extension designer or practitioner through what can potentially be a large and diverse amount of sometimes conflicting or ambiguous data. The questions in the MMM framework have been designed to be as simple, self-explanatory and user friendly as possible, in order to guide the user though a sound, logical process.

The case study topic of 'adoption of rootstocks' also worked well for a number of practical reasons:

- Rootstocks are readily distinguishable from 'own-roots' or 'ungrafted' vines, meaning that the adoption can be clearly defined and measured.
- Adopting rootstocks is not an easily reversible innovation to adopt. People may trial them, but they cannot adopt and then readily dis-adopt. Again this facilitates ease and quality of data collection.
- Rootstocks have been available to, and used by industry for many years and hence it is relatively easy to find 'adopters' and 'non-adopters' and industry experts to interview.
- The decision to adopt (or not adopt as the case may be) rootstocks is usually highly involving to grapegrowers planting or replanting vines, and hence they can readily describe the reasoning behind their decisions. This is especially useful when identifying the dimensions of perceived usefulness (drivers) and perceived ease of use (barriers).

The second case study in this series examines the adoption of the 'Lean Production for wineries' productivity analysis and improvement program.

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APPENDIX 1

Table 12: Rootstock versus own roots: information to enable grapegrowers to evaluate the potential benefits of using rootstocks

Source/author	Web (URL) or book	Description	Comment
Newson, Ratcliff and Freckleton (2012)	Supplement to powerpoint presentation "Rework or replant"	Detailed cost-benefit analysis as a supplementary sheet to a powerpoint presentation on the pros and cons of different replanting options.	Hard to access (only available by personal request). Not dated – but at least five years old. Needs more context and explanation.
Mornington Peninsula Association	mpva.com.au/exfiles/ Rootstock_selection. PDF	A single file in Powerpoint format with lots of information about selection considerations	Not easily accessible from the main site. No attribution of authorship or date. Very long. More designed to be presented than read in isolation.
eXtension (US)	extension.org	Has information about many topics. Good range of topics related to grapevines, rootstocks etc.	Up to date. Provided by University staff with expertise in the area. BUT directed at a US audience. Has reasonable applicability to Aus in general but not for specific selection of rootstock.
Nick Dry (2007)	Grapevine rootstocks	Very brief section on benefits of using rootstocks.	Has not been updated since publication in 2007. Core information is likely to be current but value proposition is not made strongly.

Table 13: Rootstocks vs own roots: information to enable grapegrowers to select the best rootstock for their site

Source/author	Web (URL) or book	Description	Comment
Vinehealth Australia website	vinehealth.com.au	Statistical information can be generated live from their database on rootstock use. Detailed summary of rootstock characteristics Comprehensive guide to choosing rootstocks Links to other information and Nick Dry book	Has not been updated for some time. May not ever be updated again given changes in staffing and direction of Vinehealth Australia.
Yalumba rootstock selector	/203.23.76.110/yalumba_nursery/rootstock/public/	Interactive selector allows you to put in requirements and be given a selection of suitable rootstocks	Currently being updated. Readily accessible and presents a lot of complex information in a user friendly way
Glenavon nursery	glenavon.com.au/Home.html	Has rootstock characteristics table. Also has information on CSIRO rootstocks (is only supplier in SA).	Primarily designed for ordering material not for education. Does not link to other information sources.
Yalumba nursery	yalumbanursery.com	Lists rootstocks available. Repeats content on rootstock characteristics as per Vinehealth Australia website. Links to Vinehealth Australia website. Link to presentation on rootstock selection – good information in PDF	Does not link to its own rootstock selector (may be because the selector is currently being updated). Gives no guidance on rootstock selection or factors to take into account. Much more information about varieties and clones and nursery processes. Primarily for grapegrowers to order material. Rootstock selection PDF is good relevant information but not in easiest format to read and no date on it. More designed to be presented than read in isolation.
Mornington Peninsula Association	mpva.com.au/exfiles/Rootstock_selection.PDF	A single file in Powerpoint format with lots of information about selection considerations	Not easily accessible from the main site. No attribution of authorship or date. Very long. More designed to be presented than read in isolation.
eXtension (US)	extension.org	Has information about many topics. Good range of topics related to grapevines, rootstocks etc.	Up to date. Provided by University staff with expertise in the area. BUT directed at a US audience. Has reasonable applicability to Aus in general but not for specific selection of rootstocks.
Nick Dry (2007)	Grapevine rootstocks	Comprehensive reference on rootstock characteristics, site factors and guidelines for choosing rootstocks in different situations.	Has not been updated since publication in 2007. Core information is likely to be current but new rootstocks and later findings eg on issues with root-knot nematodes are not included. An electronic version that could be accessed in sections would be very useful.
Fact sheet 14	Waterandvine.gwrdc.com.au	Two pages of information on breeding, classification of drought, salt and nematode tolerance	Does not link to soil type or rootstock vigour