Using the 'Market, message, means of communication framework' to guide design of grape rootstock extension

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Abstract. Growing wine grapes on rootstocks is seen by many as a key to the long-term sustainability of the wine industry. Yet adoption rates are perceived to be extremely low in many wine regions. Through interviews and a survey, based on the 'market, message and means of communication' framework, data was collected to enable the market for and the key barriers to and drivers of adoption of rootstocks to be identified. The market for rootstocks consists of grapegrowers replanting or planting new vineyards. They are likely to adopt rootstocks if they are in or near a phylloxera or nematode infested zone, have site related issues, or are seeking a risk mitigation strategy. Adoption rates can be increased by providing objective information e.g. through a central website with information on: benefit-cost analysis of rootstock versus ungrafted vines, matching rootstocks to specific site conditions, rootstock wine quality and management of grafted vines.

Keywords: Adoption, market, message, grapevine, rootstock, Australia

Introduction

Many believe it is crucial to the long-term sustainability of the Australian wine industry that new grapevine plantings be on grafted vines, consisting of a scion, or aerial component of the desired fruiting variety (mostly *Vitis vinifera* e.g. Chardonnay or Shiraz) grafted onto a different rootstock (generally non-vinifera) (Martin 2014). This belief is based on research evidence that rootstocks are better adapted to adverse conditions (e.g. saline soils, water stress) and more tolerant to pests such as phylloxera, nematodes and crown gall than ungrafted vines (Cox 2015). Some rootstocks are also reported to be more water-use efficient, come into production earlier, and produce grapes with lower potassium levels than own-rooted vines (Whiting 2012; Martin 2014). However, purchasing grafted vines adds approximately 10% to vineyard establishment costs (Martin 2014).

There are around 25 grapevine rootstocks currently available in Australia, with three new rootstocks released by the CSIRO in 2012 and further breeding and trials underway (Wine Australia 2015). Martin (2014) estimated the net benefit to the wine industry of rootstock adoption (compared with ungrafted vines and assuming current rates of adoption) would be $201 million over a 2007-2040 timeframe, with rootstock purchase costs having a two year payback period to the grapegrower. To encourage further adoption, industry, State and Federal governments and Wine Australia invested over $18 million in rootstock-related R&D from 2000 to 2012. This investment has been largely spent on rootstock breeding, trialling, evaluation under Australian conditions and extension (Martin 2014). Wine Australia, the wine industry's national research body, has since invested in further rootstock work, including updating selected extension resources (Wine Australia 2015).

Yet despite this investment, industry experts consider current rootstock adoption rates to be relatively low (Martin 2014). Information on the commercial plantings of rootstocks is variable between states and regions, with little quantitative data available on a national basis. 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% (Vinehealth Australia 2015). Meanwhile in the Murray-Darling and Swan Hill regions, 67% of new plantings are estimated to be on rootstocks (D Nitschke 2015, pers. comm., 25 August), while in Western Australia and Tasmania this figure is estimated to be less than 5% (C Bell 2015, pers. comm., 25 August). This raises questions about the drivers and barriers to rootstock adoption, realistic adoption targets and how extension can be designed to be most effective in optimising adoption.

There is an extensive range of models, tools and approaches available to guide extension design (for example see 'extension models and best practice' (Coutts and Roberts 2003), the Kaine Framework (Kaine 2004) and the ADOPT model (Kuehne et al. 2014)). These usually have a specific task, such as selection of communication methods, innovation market identification, or prediction of lag time to adoption.

Hill et al. (2015) modified the 'market, message, means of communication' framework (Huffer 2012) and proposed that it would be a sound organising mechanism to guide the collection and analysis of qualitative and quantitative data, in order to identify:

- potential market segments and target audiences for an innovation
- key drivers and barriers to adoption
- messages and information relevant to the drivers and barriers identified
- options for communicating these messages and information to target audiences.

These findings were then used to design an evidence-based extension strategy.

The 'market, message, means of communication' framework was selected for use in this research as it incorporates a range of concepts from a number of disciplines, intended to provide a practical, systematic and comprehensive approach to extension design. The authors considered this appropriate where the aim of the extension is to make information accessible to the active learners who search for it, with the role of the extension or communication agent being to translate and structure information (Leeuwis 2004, p 31).

In this study the topic of grapevine rootstocks was used as a case study to test the 'market, message, means of communication' framework as an approach to guide the collection and analysis of data and to inform an extension design strategy (Table 1).

Methods

Data collection and analysis

Qualitative and quantitative data were collected to answer the key questions in the 'market, message, means of communication' framework (Table 1). The qualitative data were collected through semi-structured interviews conducted by phone or in person, with participants selected to provide a range of views from diverse wine grape growing regions from throughout Australia, with different industry roles and perspectives.

From the interview data, a brief survey was developed. This survey was then emailed to 640 grape growers and vineyard managers, accessed from a data base purchased from a market research company, in October 2015. This survey was designed to test interview findings and provide additional detail in answer to questions 4 and 5 of the 'market, message, means of communication' framework regarding benefits and costs of adoption. The survey respondents had the opportunity to provide additional information on their opinions of rootstocks and research through a number of open questions.

For the 'information gap analysis', online and written sources were identified through a 'google' search using the terms 'grapevine rootstocks'. References listed by interviewees were also considered. Only Australian references were included, as the overseas agronomic information was not considered directly relevant to Australian conditions.

Overview of data collection

Interviews were conducted with 14 vineyard managers and winemakers, three industry experts and five nursery managers. These participants were recommended by Wine Australia staff with a long industry involvement. They were recommended as they were percieved to have a range of views, or unique expertise in regard to rootstocks. The interview participants were questioned about their vineyard enterprises (i.e. scale, location), reasons for adopting or not adopting rootstocks, benefits and costs of adoption, and about their rootstock-related information search and key questions. These topics informed questions 2, 3, 4, 5 and 6 of the 'market, message, means of communication' framework. Interviews took 15-25 minutes each and were recorded and analysed, using case and cross-case analysis (Patton 1990), between June and October 2015.

The email survey was completed by 143 grapegrowers (22% response rate). It is not claimed that this data and sample was representative of the whole industry, but rather provided a snapshot of grapegrower and winemaker attitudes to use of rootstock. Of the respondents, 50% had planted or replanted vines in the last five years, 68% of them using rootstocks, indicating that people who were interested in rootstocks were more likely to complete the survey, as the overall average rate of rootstock adoption, as discussed in the introduction, is much lower than this. Sixty-five of the respondents added comments, providing additional contextual information, quotes and opinions on rootstocks.

Additional statistical information pertaining to questions 1 and 2 was obtained from industry experts and relevant published literature.

Table 1. The 'market, message, means of communication' framework key questions – customised for the wine industry

Q	Relevant concept	Key question	Clarification or examples for developers of extension programs
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.
2	Market	Is adoption of the innovation determined or influenced by 'business outlook'?	'Business outlook' describes whether a business is contracting, staying steady or expanding in size or production. These factors influence the availability of capital, the motivation of business decision makers and the available timeframe for benefits from the innovation to be realised (i.e. immediate, medium or long term).
3	Market	Is the innovation relevant to vineyards or wineries of a certain scale, climatic zone or with specific biophysical characteristics?	Will adoption provide benefits to small, medium, large or all scale vineyards or wineries? In cool, warm or hot regions? Are there certain features of the business that make the innovation more or less relevant?
4	Market/ message	Why would people find or potentially find the innovation useful?	What are the benefits being sought? Key drivers of adoption that have been identified by Hill et al. (2015) are: increasing quality, workplace safety, managerial flexibility or reducing input costs. What are the key questions grapegrowers ask to ascertain if the innovation will provide these benefits in their business? This is the information being sought (i.e. 'the message').
5	Market/ message	What are the barriers to, and costs of adoption?	Costs include: 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. Again, this influences the information being sought ('the message'). Are there potential barriers in the sub-process required for adoption e.g. availability of product?
6	Means of communication	Where is information sought for this or a similar decision?	Is the decision to adopt high or low involvement? For high involvement decisions, people generally collect information from a range of sources over a number of months or years. Low involvement decisions are quicker with few if any sources of information used. Conduct an information gap analysis to identify opportunities for improving information provision and guiding extension design.
7	Design a strategy	Design an extension strategy	What is the best market segment to target with an extension program? What message (information) will participants seek? Where do they currently seek information, how can your program use these sources or optimise positioning of information?

Source: Modified from Hill et al. 2015.

Results and discussion

Defining the innovation

What is the innovation? (Question 1) The innovation is defined as grafted grapevines, consisting of a rootstock component and a scion, or aerial component of the desired fruiting variety (e.g. Chardonnay or Shiraz). *From the interviews, it was determined that grapegrowers use rootstocks when either:*

- planting new vineyards or expanding existing vineyards or
- replanting existing vineyard area.

Influence of business outlook

Is the adoption of rootstocks influenced by business outlook? (Question 2) Business outlook describes whether a business is expanding, staying steady or contracting in size or production, and has been identified as a key influence on the technologies or innovations that are adopted by business decision makers (Hill et al. 2015).

Vineyard expansion is most likely to be undertaken by businesses with an 'expanding' business outlook as the timeframe for realisation of benefits is medium to long term, it represents a 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 surveyed at that time (2014) were in the 'expanding' market segment.

Grapegrowers most commonly replant in existing vineyard areas to change varieties, or due to pest or disease issues or age-related loss of productivity (Whiting 2012). Replanting a vineyard requires a lower capital investment than planting a new vineyard area as the vineyard infrastructure is usually already in place. Therefore, grapegrowers who are replanting are more 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, considered part of the investment.

The rate of new planting or replanting of vineyards in 2014-15 was 1% or 1,234 hectares, equating to 2-2.5 million new plants per year across Australia (ABS 2015). 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. This constitutes the maximum potential size of the market for rootstocks. 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).

Grapegrowers whose business are contracting in size, are extremely unlikely to plant or replant vines.

Influence of scale, climatic zone of biophysical characteristics

Are rootstocks only relevant to vineyards of a certain scale, climatic zone or with specific biophysical characteristics? (Question 3) Based on the interviews, there was no evidence that the relevance of rootstocks was systematically influenced by vineyard scale, climatic zone, soil type, access to irrigation water or grape scion variety in a way that could be usefully generalised across regions.

Is the innovation useful

Why would people find, or potentially find, the innovation useful? (Question 4) How useful a grapegrower or winemaker perceives an innovation to be has been identified as the strongest driver of adoption in the wine industry (Hill et al. 2015). The reasons a grapegrower or winemaker would perceive an innovation to be useful vary depending on the innovation under study; however, there are some common themes around increasing productivity. Specifically, perceived usefulness relates to the ability to:

- Reduce input costs, including labour.
- Maintain or improve grape and/or wine quality or yield.
- Increase workplace safety.
- Increase managerial flexibility (Hill et al. 2015).

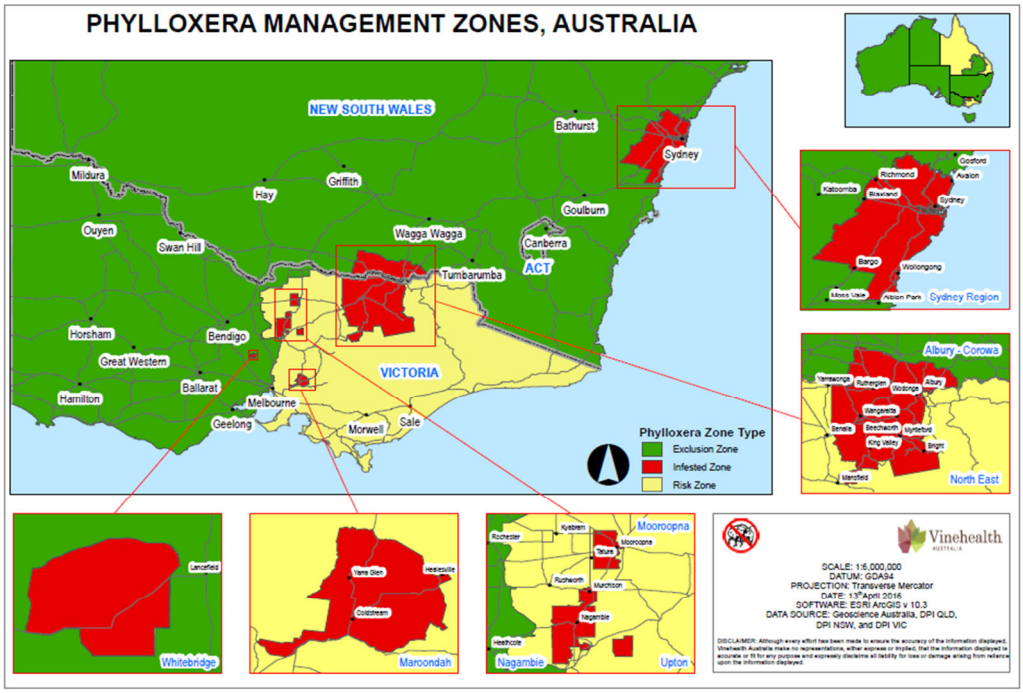
Survey respondents said they adopted rootstocks:

- As a risk management strategy - e.g. for potential future phylloxera or nematode infestation, climate change (34%).
- To influence scion vigour e.g. in Merlot (19%).
- As a trial (11%).
- Because the vineyard is in a phylloxera zone (11%).
- Because the vineyard is nematode infested (9%).
- To manage site related issues e.g. salinity, water availability, vigour or varietal issues (9%).

The majority of these reasons relate fundamentally to the grapegrowers' need to maintain or improve wine grape quality or yield. Further discussion of the main reasons listed is given below.

Phylloxera infestation and risk management All the interviewees believed that grapegrowers planting or replanting in or near a phylloxera-infested region (Figure 1) would use phylloxera-resistant rootstocks. The spread of phylloxera is considered inevitable over short distances and ungrafted vines have little phylloxera tolerance, so if they did establish they would not be productive or would die (Whiting 2012).

Figure 1: Phylloxera management zones. Red areas are infested, yellow areas status unknown, green areas phylloxera free



Source Vine health Australia

The survey results reflected this opinion with many respondents that used rootstocks either being in a phylloxera zone already or planting in case of future infestation. As one interviewee said 'Western Australia is phylloxera free and if it does arrive we will be in deep trouble, so we are trying out some rootstocks to see which will suit our site, and then we will start planting these'.

Another interviewee noted that he had planted on Ramsay rootstocks, which after doing some research he had decided would enhance the resilience of his vines in the difficult and variable climatic conditions he is expecting as a result of climate change.

Nematode infestation A number of interviewees and survey respondents had adopted rootstocks due to their vineyard soils being nematode-infested. Soil previously planted to grapevines or a number of other crops including citrus is likely to suffer a build-up of nematodes over time, particularly in soils with a high sand content (Cox 2015). Nematodes are a soil borne pest that feeds on vine roots resulting in a loss of vigour and subsequent yield decline (Martin 2014).

In general, phylloxera resistant rootstocks are also nematode resistant (although recent evidence has suggested that some rootstocks have insufficient resistance to a particular type of nematode); therefore, a decision to plant on rootstocks for nematode resistance will provide the additional benefit of insurance against phylloxera. Ironically, however, sandy soils are the least conducive to phylloxera establishment. Nematode prone regions include the Riverland, Murray-Darling and Swan Hill regions (Martin 2014).

Scion vigour management, reduced water use, site related issues and climate change Some rootstocks have superior tolerance to drought conditions, waterlogging and/or salinity, and/or can be used to reduce or increase scion vigour (Whiting 2012, Martin 2014). These benefits were raised by some grapegrowers in the interviews and the survey as influencing their decision to adopt rootstocks in their vineyards.

Barriers and costs of adoption

What are the barriers to, and costs of adoption of rootstocks? (Question 5) A number of barriers to rootstocks use were raised during the interviews and confirmed in the survey. It was found that 32% of the survey respondents had planted or replanted vines in the last five years but had **not** used rootstocks because:

- They consider there is a low risk of phylloxera coming to their region (30%).
- There is an additional cost of rootstocks compared to ungrafted vines (17%).

- They are concerned that the rootstock vine would not perform as well as ungrafted vine (17%).
- They do not have nematodes or site related issues (17%).
- They are concerned that winemakers would be less likely to buy the fruit (4%).

Additional cost of grafted vines Grafted vines using rootstocks are double the price of ungrafted vines. This adds approximately 10% to vineyard development costs, or about $4000/ha extra if replanting (Martin 2014). In interviews, it became obvious that the additional cost of rootstocks only became a barrier to adoption if the rootstocks are perceived to be unnecessary, i.e. in regions distant from existing phylloxera infestations, without nematode pressure or site related issues. 'All of our vineyards are planted on own roots. There is no Phylloxera in WA' (survey respondent).

Difficulty in selecting the 'best' rootstock or concern that rootstocks would not perform as well as ungrafted vines Seventeen percent of the non-adopting survey respondents were concerned that rootstocks would not perform as well as ungrafted vines in their vineyard site. As the growers interviewed explained, in areas with little history of rootstock use, where there is little local knowledge and experience or regional rootstock trials, it can be difficult to predict the performance of a particular rootstock. This is because each wine region is unique in terms of soil types, rainfall and other site-specific characteristics. Therefore, rootstock trial or performance data is not directly applicable across regions.

There was widespread agreement among interviewees as well as in the literature 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 rootstock-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.

In one interview, the grapegrower told of a neighbour's experience of planting rootstock vines that never yielded commercial quantities of fruit, resulting in financial devastation. Experiences like these – while usually isolated and non-representative - can strongly influence the behaviour and opinions of other grapegrowers.

Rootstock wine quality concerns Some grapegrowers and one industry expert interviewed commented that there is a belief that rootstocks lead to poorer quality wine, so winemakers are less likely to purchase the grapes produced. A small number of survey respondents confirmed this as an issue. This is a complex issue. In warm regions, concerns about rootstock and grape quality have anecdotally been present for many years, though one industry expert suggested that attitudes were changing and winemakers now recognised that any quality issues were more likely to be caused by vineyard management rather than by grafted vines per se.

In cool premium wine regions e.g. Yarra Valley, there is little local knowledge about rootstock/ clone combinations, with one interviewee also explaining that nothing was known about how wine made from grafted vines from that region would age over a 10-20 year period. This is particularly important to winemakers selling wine at a high price point to customers with the expectation that the wine will age well.

However, a number of interviewees noted that vines on rootstocks can produce high quality grapes and wine, as evidenced by the fact that all vines in France are grafted, as are vines in many highly regarded vineyards in the Rutherglen, Glenrowan and Nagambie (phylloxerated) regions.

Potential barriers in the adoption sub-processes

The grapegrowers interviewed were asked about the steps involved in their adoption of rootstocks. The purpose of this process is to identify potential barriers or costs in the adoption sub-processes. Subsequent interviewees were then asked if they had found these factors to be barriers to adoption (Table 2).

Selecting, ordering and purchasing rootstocks 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 previously. 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. This issue needs to be resolved with the individual nursery that the grapegrower is dealing with.

Table 2: Adoption sub-processes and potential barriers.

Adoption sub-processes	Potential barriers to rootstock use	Interviewee comments
Selecting rootstocks	Difficult to get local or site specific information on how different rootstocks will perform	Raised as an issue by a range of grapegrowers
Ordering and purchasing rootstocks	Lack of availability of preferred rootstock/scion combination	Found to be an issue by a small number of grapegrowers
Planting rootstocks	Incompatibility between rootstocks and clones	Raised as a concern by some survey respondents Interview data suggests this issue is minimised if the vines are bought from a reputable nursery
Managing rootstocks	Managing rootstock vines compared with own-rooted vines	One survey respondent listed this as an issue

Disease and incompatibility issues Rootstock diseases and incompatibility with scion material have previously been reported as an issue (Whiting 2012), particularly in planting material supplied when demand greatly exceeded supply and many sources of propagating material were used. While some interviewees 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 raised these issues, suggesting they are not currently a significant barrier to adoption.

Managing rootstocks versus ungrafted vines Perceived difficulty in implementing, learning how to use, or training others in the use of technologies have previously been identified as barriers to adoption (Hill et al. 2015). While in most cases interviewees said that rootstocks were no more difficult to manage than ungrafted vines, a small number of survey respondents had found managing rootstock suckers to be difficult and costly.

Sources of information

Where is information sought? (Question 6) Unless they had previous experience with rootstocks, those interviewed said they usually did considerable research over months or years and used multiple sources, sometimes a number of times during their decision-making process, suggesting that the decision to grow grafted vines and/or selecting the best rootstock is a high involvement decision. The sources of information referred to by interviewees are shown in Table 3.

Information gap analysis

An analysis of existing rootstock-related sources of information and content was undertaken and compared with the information being sought by the target market to highlight requirements and opportunities for an extension strategy. For practical reasons, the focus was on written and on-line materials and was accessed and evaluated as to whether it provided benefit-cost information, could guide rootstocks selection to suit 'local' conditions and if it showed up in a Google search. For practical reasons this list has been limited to one page (Table 4). Analysis of the complete list resulted in the following observations:

- A range of general rootstock information is available on-line (i.e. history of rootstocks, general features), some of which is repeated on a number of sites.
- There is no central website for information. Interviewees suggested that objective, reliable, current, well-structured and designed information can be difficult to find.
- Some of the technical information is outdated (or undated), poorly designed or unclear regarding authorship.
- There is little or no linking of information (i.e. information is fragmented so the searcher must look on a number of sites).
- There are some excellent comprehensive educational resources, but the information is not readily accessible to all grapegrowers (i.e. book/ report length, ease of obtaining book).

Table 4. Overview of selected written and online rootstock related information resources

Source/author	Web (URL) or book	Description	Comment	Benefit:cost information?	Guide selection for 'local' conditions?	Shows in Google search?
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	Has not been updated for some time.	no	yes	yes
Horticulture Industry Network	http://www.hin.com.au/	Links to pdf file containing comprehensive and readily understandable information, including trial results to guide rootstock selection	Written in 2003 and does not contain information on more recent rootstocks or research.	no	yes	yes
Yalumba rootstock selector	http://203.23.76.110/yalumba_nursery/	Interactive selector allows you to put in requirements and be given a selection of suitable rootstocks. This tool does not include all commercially available rootstocks	Readily accessible and presents a lot of complex information in a user friendly way.	no	yes	yes
Glenavon nursery	glenavon.com.au	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.	no	yes	yes
CSIRO rootstocks	http://www.kcvines.com.au/	One page guide to three rootstocks recently released to industry by the CSIRO	Very specific to the three new rootstocks, some trial data provided.	no	no	yes
Mornington Peninsula Association	mpva.com.au/	A single file in Powerpoint format with lots of information about what to consider when selecting rootstocks	No attribution of authorship or date. Very long. Designed to be presented rather than read in isolation.	no	yes	yes
Nick Dry (2007) Lythrum Press, Adelaide, SA	Grapevine rootstocks selection and management for South Australian vineyards	Comprehensive reference on rootstock characteristics, site factors and guidelines for choosing rootstocks in different situations. Well respected by industry.	Not updated since 2007. Core information is current but new rootstocks and recent research results are not included.	yes	yes	no

Table 3: Types and sources of information

Type of information	Source of information
Interpersonal	Fellow grapegrowers with rootstocks
	Local vineyards or rootstock trial sites
	Industry associations (e.g. the Mornington Peninsula Wine Growers Association are active in this area)
	Winemakers and grower liaison officers
	Vine Nursery managers (e.g. Chalmers, Yalumba, KC nurseries)
	Researchers/extension officers/consultants (e.g. John Whiting and Peter Clingeleffer who are experienced and well-known in the industry)
Written/ on-line	Online resources (e.g. Vinehealth Australia website, Yalumba rootstock selector, nursery websites)
	Books or reports (e.g. 'Choosing rootstocks' by Nick Dry 2007)

Designing an extension strategy

A sound extension strategy should reach the optimum number of relevant people as effectively as possible, making key information accessible to support decision-making. This should reduce the time required for the target audiences to seek the information, and provide access to quality information, speeding up adoption and reducing the risk of mispurchase (Leeuwis 1999). 'This involves not only adapting and translating insights from various sources into a language and terminology that audiences can relate to, but also ordering and grouping together information in such a way that they can find it' (Leeuwis 1999, p 242).

The interviewees all said that deciding to plant, and selecting suitable rootstocks was an important decision. This provides opportunities for extension efforts as the decision-makers are therefore likely to seek information from a number of sources. Since information-seeking patterns have been found to be complex and varied, multiple types of information (i.e. written, visual, audio) should be integrated into information systems to cater to individual variations in information-seeking needs (Sonnenwald et al. 2001).

In the following section, the key findings from the research are summarised and used to make recommendations on an extension strategy and how to integrate it into an information system.

The market for rootstocks

Grapegrowers who are planting new vineyards or replanting existing vineyards are in the market to adopt grapevine rootstocks. Generally, these growers will have an expanding or steady business outlook. Grapegrowers in or close to phylloxera or nematode infested regions or sites are particularly likely to use rootstocks if replanting. Other 'market segments' are grapegrowers with site-specific issues (e.g. salinity, low water availability), grapegrowers who need to manage vine vigour and grapegrowers who plant rootstocks as a trial or a risk management strategy. These vineyards can be any size and can be in most wine regions – although regions vary in terms of overall climate, soil type and water availability.

Extension 'messages' or information being sought

Grapegrowers in the target market will seek information on the potential benefits and costs of using rootstocks. The specifics of these benefits and costs are presented above. The following section contains suggestions on opportunities to address the barriers to adoption and highlight potential benefits of rootstock use.

Issue 1 Rootstocks are more expensive to purchase than ungrafted vines.

Opportunity 1 Provide an economic analysis on the financial costs and benefits of using rootstocks versus ungrafted vines in various (non-infested) sites.

Issue 2 Difficulty in selecting the 'best' rootstock for a specific vineyard site

Opportunity 2 Provide information to guide decision making about which rootstocks are 'best' for a specific vineyard site. 'Best for site' may include: the desired rootstock property (phylloxera resistance, drought tolerance, vigour), expected yield (i.e. tonnes per hectare), quality implications, suitability to a range of soil types and varietal and clonal compatibility.

As one survey respondent commented, 'the correct rootstocks with the appropriate scions matched with the relevant soils and climates are the future'. Another respondent suggested:

> It would be good to have a decision tree for useful rootstock selection, with the ability to dial up/down particular characteristics, based on current research.

This has been done and is a web-based decision support tool called the "Grapevine rootstock selector" (see http://www.grapevinerootstock.com/). This tool structures and filters a large amount of complex information, making the information more accessible to users. This selector was released November 2016, contains information on 22 rootstocks, but has yet to be evaluated by industry.

Issue 3 Wine quality concerns.

Opportunity 3 Provide research results and testimonials from respected winemakers on rootstock wine quality. Provide a balanced perspective, highlighting the diversity of views and the opinions of 'experts'.

Issue 4 Concerns about managing rootstock suckering.

Opportunity 4 Provide information about which rootstocks are likely to sucker and how to best manage this risk. Video clip demonstrations and an online forum where grapegrowers can share experiences and tips and submit questions are likely to be effective.

The means of communication

In this section we consider where grapegrowers source information, and any other data or suggestions from interviewees or survey respondents on how they would like to receive information. This section should address gaps, and build on strengths identified in the information gap analysis.

Recommendation 1: That an independent rootstock 'expert' is made available to industry. They will provide information, opinions and act as a sounding board in regard to matching rootstocks to site and desired wine style. The growers interviewed and surveyed often said they had, or would like to talk to someone independent with 'hands on' experience and a good depth of knowledge.

Recommendation 2: That regional rootstock trials be continued, or resources permitting, expanded to new regions. Many of the growers interviewed and surveyed said they had gone to regional trials where possible, or vineyards in sites similar to theirs, to view the vines and talk to the vineyard manager before making their decision. A number of growers were loath to make a decision without this type of information.

Recommendation 3: That a central online source of rootstock related information be created, run and updated by an independent organisation (i.e. not a vine nursery). This suggestion is made because grapegrowers in the market for rootstocks are geographically dispersed, usually seek information online and the information they seek is often complex and technical, hence the suggestion to restructure or redesign online extension resources, using a central website.

A central location for online information would be valuable for locating key, credible, non-commercial rootstock information, reducing information seekers' confusion, fatigue and need to verify information. Links to high quality websites and other sources of more detailed or supporting information should be integrated into the text.

Recommendation 4: Online site should encompass a range of sources. Grapegrowers value interpersonal communication from peers and experts. While this is not always possible, online information can now be presented in visual forms (i.e. videos), audio (i.e. podcasts) and interactive (e.g. rootstock selector, interactive maps), making information more accessible, usable and interesting. Online forums are another option that would enable interpersonal communication (see below).

Recommendation 5: Rootstock information should be designed using current 'best practice' design principles. These principles provide guidance on site appearance and structure and encompass research information on how people interact with and use information. For example see resources provided by the Nielsen Norman group (https://www.nngroup.com/articles/ten-good-deeds-in-web-design/).

Recommendation 6: An on-going web-based chat forum should be developed. Again, this recommendation refers to people's liking for peer-based, specific information. A chat forum would enable grapegrowers from different wine regions to communicate with other growers and industry experts, sharing ideas, anecdotal evidence and contacts. This forum should be moderated by an independent rootstock expert and should show up in a search using a search engine. This would address the issue raised by an interviewee: 'If you were new to the industry

and did not have the connections it would be very difficult to know who to talk to for sound rootstock advice'.

Conclusion: Using the 'market, message, means of communication' framework.

The 'market, message, means of communication' framework was applied to the case study of adoption of rootstocks and was found to be a useful tool for ensuring that information was systematically collected, analysed and used to inform extension program design. This enabled assumptions of program designers to be challenged and either validated, refined or replaced. Use of the framework also provided an organising mechanism to guide the extension designer or practitioner through a potentially large and diverse amount of sometimes conflicting or ambiguous data. The questions in the 'market, message, means of communication' framework were 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-rooted vines, meaning that the adoption can be clearly defined and measured.
- Adopting rootstocks is not an easily reversible innovation. 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 rootstocks (or not adopt as the case may be) is usually highly involving to grapegrowers planting or replanting vines, 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).

Ultimately, the effectiveness of the 'market, message, means of communication' framework can best be measured by implementing the extension recommendations outlined above and measuring change in adoption of rootstocks. The recommendations made in this case are largely focused on internet-based resource development, combined with strategic use of local resources such as regional trials and an independent 'rootstock expert' to provide personal advice. This is considered the best strategy for this particular innovation, because of the large size and geographical spread of the target audience for rootstocks as well as gaps in current resources available and an assessment of the likely return on investment for the extension program. Different innovations will require different strategies based on specific information obtained through the application of the framework.

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