Australian Government

Australian Grape and Wine Authority

Cost benefit analysis of winegrape rootstock research, development and extension

FINAL REPORT to

AUSTRALIAN GRAPE AND WINE AUTHORITY

Project Number: **GWR 1308**

Principal Investigator: **Greg Martin**

Research Organisation: **IDA Economics Pty Ltd**

Date: **28 November 2014**

Contents

Summary

The Australian Grape and Wine Authority (AGWA) invests in and directs research, development and extension (RD&E) along the whole value chain 'from vine to glass' to enhance the profitability, competitiveness and sustainability of the Australian wine sector.

Between 2000 and 2014, AGWA (formerly the Grape and Wine Research Development Corporation) funded 26 rootstock related research and development (R&D) projects with a value of $18.6m (2014 real dollars i.e. adjusted for inflation), present value terms (5% discount rate). AGWA funding contributed about half of the total, with the vast majority of the balance coming from The Commonwealth Scientific and Industrial Research Organisation (CSIRO), Plant Industry research division.

When grapevine scion is grafted onto rootstocks, there are many benefits compared with own-rooted vines, including:

- resistance against phylloxera,
- resistance against various nematodes,
- production commences sooner following vineyard establishment,
- improved water use efficiency,
- reduced potassium uptake, and
- increased salt tolerance.

The cost benefit analysis focused on several key benefits where data sets were available to be quantifiable. The key areas and major outcomes of rootstock use included:

- **Phylloxera:** use of tolerant rootstocks in Phylloxera-infested areas of the Yarra Valley (Vic) were estimated to avoid an expected net income loss by 8% (for the region). Own-rooted vineyards may face substantial crop loss and lose the majority of vineyard income following a Phylloxera infestation;
- **Nematodes:** nematode-resistant rootstocks avoided yield losses estimated at 10%
- **Vineyard establishment and production:** the nature of rootstocks saw new vineyards come into production one year earlier compared to own-rooted vines;
- **Water use efficiency:** larger root systems, improved water regulation and transport around the vine has increased water use efficiency (WUE) by 20% in rootstocks compared with own-rooted vines;
- **Potassium exclusion:** reduced potassium levels in must were estimated to save wineries $12/tonne by avoiding unnecessary pH adjustments in the winery; and
- **Shorter time to production:** the additional cost of rootstocks, compared with own-rooted vines, was returned within two years of planting, an estimated gain of one year.

While rootstocks have been observed to deliver a range of additional benefits, during this analysis, insufficient data were available to quantify all of the observed benefits. Given only a proportion of benefit of rootstock use has been quantified, the estimated return on investment from AGWA and co-investors into rootstock R&D is conservative.

The proportion of vineyard planted onto rootstocks compared to own-rooted vines provides an indication of 'adoption' of rootstocks, but this alone is a coarse measure as it does not differentiated between various replanting scenarios.

In this study the adoption of rootstock was separated into:

- rootstocks planted in new vineyards (ie: areas previously not planted to grapes);
- own-rooted vines being replaced by rootstock grafted vines and
- rootstock grafted vines being replaced with an improved or alternative rootstock.

The net industry benefit was estimated at $201m (Table 1) over a 2007-2040 timeframe (in 2014 dollars). Around 64% of the estimated benefits were derived from nematode resistance, 22% from bringing production of new plantings forward and 14% from improved WUE.

Outcomes from the research were estimated to return gains to industry of around $11 for each $1 of R&D investment (using a real discount rate of 5%).

Table 1: Investment performance: GWRDC rootstock program: 2014 real present values (discount rate 5%)

Present value benefits	$m	$269
Present value adoption costs	$m	($68)
Present value net benefits	$m	$201
Present value R&D costs	$m	($19)
NPV from R&D investment	$m	$182
Benefit cost ratio		11
IRR		35%

It should be noted the estimate is conservative: not all benefits have been considered and attributes such as yield gains from nematode resistance and improved WUE are likely underestimated. Applying higher yield gains, the estimated rate of return increases markedly (Table 15) and suggests a benefit cost ratio as high as $20 for each $1 invested.

Background

The Australian Grape and Wine Authority (AGWA) invests in and directs research, development and extension (RD&E) along the whole value chain 'from vine to glass' to enhance the profitability, competitiveness and sustainability of the Australian wine sector.

Between 2000 and 2014, AGWA (formerly the Grape and Wine Research Development Corporation) funded 26 rootstock related research and development (R&D) projects with a value of $18.6m (2014 real dollars i.e. adjusted for inflation), present value terms (5% discount rate). AGWA funding contributed about half of the total, with most of the balance coming from CSIRO Plant Industries.

AGWA commissioned an independent evaluation of investment into rootstock related R&D. Readers should note that investments made prior to 1 July 2014 were made by GWRDC, but are referred to as AGWA investments.

Approach

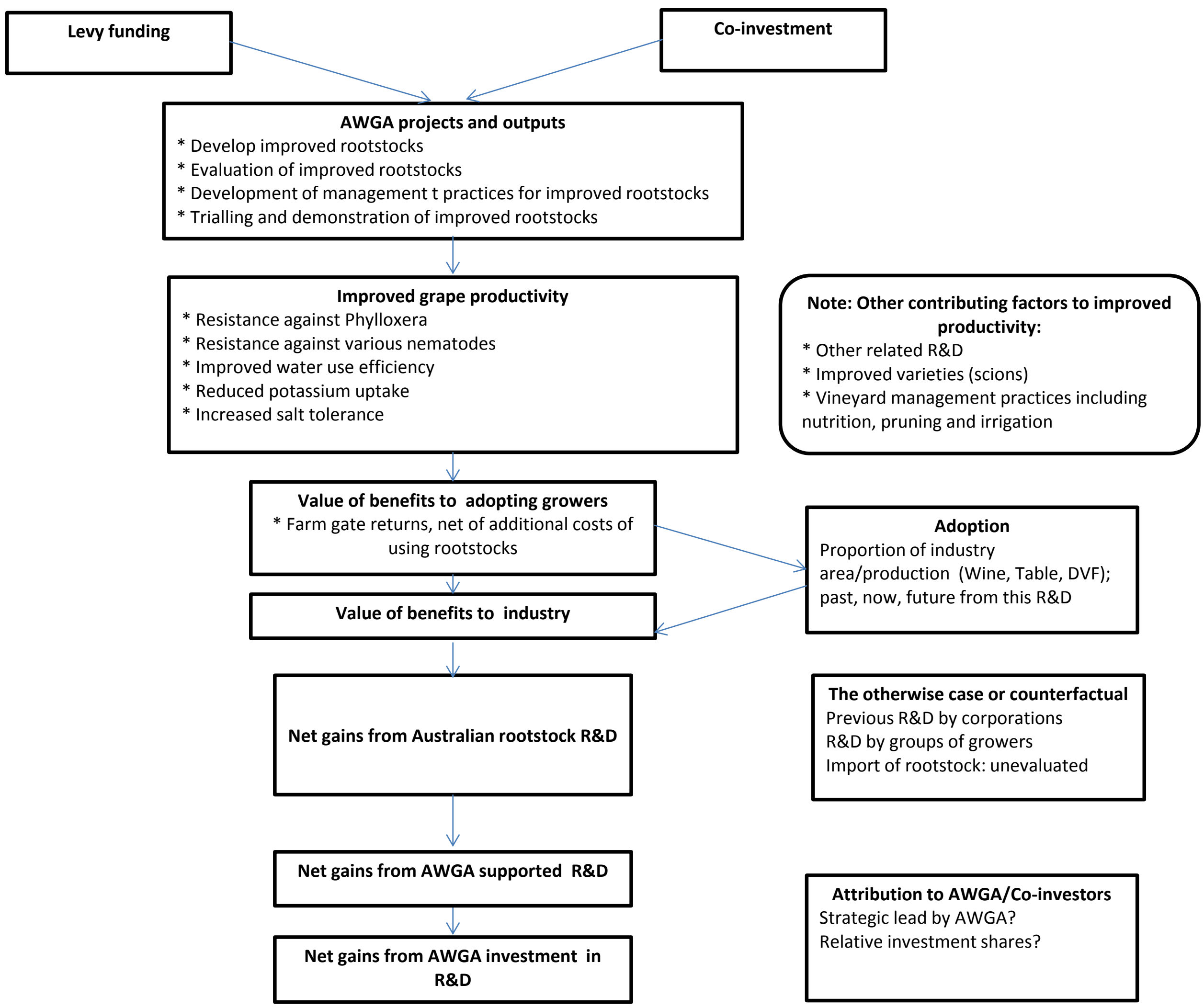
The evaluation was undertaken by IDA Economics and has been conducted within the standard framework developed by the Council of Rural Research and Development Corporations. Key activities as part of the evaluation included:

- Identifying past AWGA investment projects in rootstock R&D,
- Outlining the financial investment into each R&D project (AGWA and co-investment, recognising that there is often direct grower 'in kind' investment not included in project financial data),
- Outlining the outputs from the R&D – what did the R&D produce in the way of information about rootstock performance and rootstock management and new rootstocks,
- Assessment of commercialisation/implementation costs necessary for growers to adopt the rootstock research findings,
- Estimating the outcomes, specifically, adoption levels and application of the new information/rootstocks across the wine grape industry (and in dried and table grape industries), compared to the otherwise scenario (ie: without AGWA's R&D investment and the new information resulting from that investment),
- Where possible, delineating and estimating the benefits to grape growers , compared to otherwise scenario[1](ie: without AGWA's R&D investment), ie the increase in grower profitability as a result of adopting the R&D findings,
- Adjusting the costs and benefits to reflect real present values, using an predetermined discount rate,
- Determining the investment performance by calculating the measured net benefits, benefit-cost ratio and internal rate of return (IRR),
- Estimating the distribution of benefits across grape growing industries, and between regions
- Defining the nature and extent of any non-measured (intangible) benefits to the grape growing industries and any spillover benefits to other industries or the community more generally.

The approach is summarised in Figure 1.

Figure 1: Approach to cost benefit analysis for rootstock research, development and extension

[1] It is standard practice in cost benefit analysis, including cost benefit analysis of R&D investment, to measure the estimated benefits as the benefits compared to what might have otherwise happened (without the R&D). The otherwise case is often called the counterfactual.



R&D investment (cost)

The AGWA projects funded between 2000 and 2014 (

Table 2) are calculated to have involved a total investment (AGWA plus co-investor) valued at $18.6m in 2014 real (ie: adjusted for inflation), present value terms. AGWA is calculated to have invested $9.1m– about half of the total.

The principal co-investor has been CSIRO with contributions also from the (then) Victorian Department of Primary Industries and the South Australian Research and Development Institute (SARDI).

Table 2: Investment into rootstock R&D projects between 2000 and 2014

ProjectNo	Project Title	Year	Total project cost ($ of the day)	AWGA funding ($ of the day)
RT 99/14	Matching rootstock and scion combinations	2000	$34,649	$15,000
RT 00/7	Matching rootstock and scion combinations to environmental conditions in the Murray Valley, and evaluation of seven commonly used rootstocks in the region, grafted to the varieties Chardonnay, Shiraz and Cabernet Sauvignon	2000	$32,281	$15,000
RT 01/30-4	The publication of a guide to the selection of grapevine rootstocks and clones in Greater Victoria	2002	$22,740	$9,750
UA 01/08	Clonal and rootstock effect on Vitis vinifera cv Merlot berry development	2002	$13,050	$4,550
RT 02/05-1	Rootstock analysis planting tool (RAPT)	2003	$17,380	$8,560
RT 02/31-4	South Australian regional rootstock review	2003	$37,700	$15,000
RT 01/03	Matching rootstock and scion combinations to environmental conditions in the Murray Valley	2003	$39,415	$15,000
SAR 00/6	Identification of virus free clones of the winegrape varieties and rootstocks required in Australia to enable the establishment of elite nuclear source collections for vine improvement schemes	2002	$318,249	$219,040
RT 02/19-3	Matching rootstocks and scion combinations in Sunraysia	2003	$50,187	$13,000
CRV 99/8	Improving water use efficiency, canopy structure and grape quality by better matching rootstock and scion physiology to irrigation practice (2.1.1)	2002	$661,826	$223,404
CRV 02/04	Sustainable salt exclusion by 'salt tolerant' rootstocks (2.3.5)	2003	$179,119	$153,239
RT 05/03-4	Rootstock review for the Alpine Valleys Region, Victoria	2006	$16,980	$11,000
RT 04/11-3	The influence of 3 rootstocks on vine performance and the composition and sensory properties of wine from early, mid and late maturing clones of Pinot Noir	2006	$22,363	$12,948
CSP 99/2	A systematic and smarter approach to breeding and developing grapevine rootstocks adapted to Australian conditions	2005	$1,530,405	$474,998
CSP 06/05	Grape composition and wine quality from salt excluding rootstocks and characterisation of the chloride exclusion mechanism	2008	$1,494,276	$814,507
CSP 05/03	Rootstock breeding program	2009	$2,029,063	$1,302,419
SAR 0903	Salt tolerant rootstocks for long-term sustainability in the Limestone Coast	2010	$168,765	$162,068
GWR 1009	Rootstock breeding and associated R&D in the viticulture and wine industry	2011	$30,386	$30,386
DPI 08/01	The three Rs - Rootstock, Resistance and Resilience to grape phylloxera	2010	$976,953	$469,491
GWT 1201	Identification of anion transporters that confer chloride exclusion and salt tolerance to grapevine rootstocks	2012	$2,495	$2,495
CSP 1101	Rootstocks to meet future challenges of the Australian wine industry	2012	$222,406	$160,000
CSP 0901	Achieving water use efficiency and improved drought tolerance with rootstocks	2011	$1,768,728	$844,277
GWR 1303	Rootstock Selector Tool	2014	$5,100	$5,100
GWR 1304	Rootstock Selector Tool	2014	$3,500	$3,500
CSP 1002	Delivering chloride and sodium excluding rootstocks for quality wine production	2012	$1,977,381	$814,003
GWR Ph1004	The effects of genotype and root traits on Cl exclusion mechanisms in grapevine rootstocks	2012	$35,850	$35,850

Source: AWGA

R&D outputs

The key findings from the rootstock projects completed since 2000 (listed in table 2) are presented in Appendix 1.

A recently completed review of rootstock breeding in Australia by Whiting (2012) provided a comprehensive guide of what has been achieved from AGWA project investments, Australian rootstock breeding and rootstock use across Australia.[2]

Whiting's review (2012) highlighted rootstocks were widely planted across many international winegrape growing regions, particularly in Europe where phylloxera devastated most own-rooted plantings. The review also noted some Australian wine regions are planted almost exclusively to rootstock while many other regions have little or no rootstocks planted and favour own-rooted plantings.

---

2 Whiting, J 2012, *Rootstock breeding and associated R&D in the viticulture and wine industry* (GWR 1009), Australian Grape and Wine Authority, Adelaide, Available from: <http://research.agwa.net.au/wp-content/uploads/2012/11/Rootstock-Review-John-Whiting-FINAL-web.pdf>. [17 August 2014].

The review (Whiting 2012) observed that while R&D prior to 1990 focussed primarily on phylloxera,

> *Research since the late 1980s focused on rootstocks with reduced potassium uptake to address high juice pH issues, combined with evaluating the rootstocks for phylloxera and nematode resistance, ease of grafting and propagation and restricting the uptake of ions, such as sodium and chloride (Wheal et al., 2002). The work now includes assessing vigour potential, WUE and the impact on wine quality (Whiting 2012, pg. 27).*

In addition, Whiting (2012) noted that,

> *Earlier on, the industry focused on nematode and phylloxera tolerance and relied on parentage to match the general soil and climate conditions. More recently, following the drought, the focus has changed to increased WUE, drought tolerance and salt tolerance. Furthermore, the surplus in grape production has increased the focus on better grape and wine quality. The main reasons for using rootstocks will continue to change over time in response to conditions prevailing in the industry (Whiting 2012, pg. 7).*

Since 2000, the key outputs from the R&D have been development of new rootstocks and information on use and performance of rootstocks, including:

- Development and release of new rootstocks, including three from CSIRO (list names).
- Information regarding underlying disease issues and disease status between and within vineyards. The spread of phylloxera has been documented by Powell (2012)[3]. Clingeleffer (2011) identified nematodes as an issue for some newly planted vineyards as well as older vineyards planted on rootstocks which may require improved rootstocks given nematode population has built-up and tolerance of nematodes by some older rootstocks has begun to break down.[4]
- Data demonstrating improved WUE, drought tolerance, salinity tolerance, reduced potassium uptake..
- Information for grapevine nurseries and grape growers on rootstock performance and rootstock-scion interaction for specific vineyard site attributes or grape specifications (eg: online tools including Yalumba Rootstock Selector, Chalmers Nurseries Rootstock data and Glenavon Nurseries Rootstock Guide)
- Vine management strategies required when using rootstocks.
- Extension activities to demonstrate and promote the benefits of rootstock use to the wine industry.

R&D value (benefit)

Estimating the value of the R&D investment requires consideration of two main factors:

- Benefits of R&D - what rootstocks and information has been delivered by R&D which is available for use by growers to improve profitability

---

[3] Powell, K 2012, *The three Rs – Rootstock, Resistance and Resilience to grape phylloxera* (DPI 08/01), Australian Grape and Wine Authority, Adelaide, Available from <http://research.agwa.net.au/wp-content/uploads/2012/11/DPI-08-011.pdf>.[17 August 2014].

[4] Clingeleffer, P and Smith, B 2011, *Rootstock breeding program and development for Australian wine grapes* (CSP 05/03), Australian Grape and Wine Authority, Adelaide. Available from <http://research.agwa.net.au/wp-content/uploads/2012/09/CSP-05-03.pdf> [17 August 2014].

- Otherwise case - what growers might have done, to date and in the future, in the absence of the current R&D effort – the so called 'counterfactual'.

Measuring the benefits of R&D

In most situations, growers will plant a particular rootstock for a few key attributes. Other attributes are either considered a 'bonus', are not viewed as significant or do not benefit the grower.

In some cases, there may actually be significant trade-offs in selecting between rootstock or between rootstocks and own-rooted vines. For example, improved WUE may cause excess vigour adversely impact on fruit quality if not appropriately managed or the wine buyer may simply not prefer grapes grown on rootstock.

The AGWA funded R&D has made choosing between own–rooted vines and rootstocks or between rootstocks easier for growers. When estimating the benefit to growers in the analysis, careful consideration was given to the value of benefits. In some situations, all benefits of a particular rootstock may not be applicable while in others situations, selection of a rootstock for one key attribute may also address other issues. For example, if phylloxera resistant rootstock has enabled continued production (and profit generation) in a region, the same continuation of production cannot also be claimed for nematode resistance.

For the analysis, a level of disaggregation was required to:

- reflect the range of rootstock attributes and the relevance of those issues across the industry,
- the range of potential gains from rootstock, depending upon the vineyard situation,
- reflect the value of benefits to growers over time,
- reflect rootstock use across the three grape industry segments (wine, table and dried vine fruit),
- avoid double counting of overlapping gains (for example, both nematode and phylloxera gains from rootstock),
- assess short term and long term gains. For example, current research on phylloxera (such as maintaining rootstock genetic resources) may not have near term application but provides for future R&D and ultimately, wine industry benefit.

The otherwise case

In the absence of the AGWA R&D, there would still have been continuing interest in using rootstocks but information and available choices would have been limited now and into the future.

Given the historical focus of rootstock selection internationally was for phylloxera and nematodes tolerance, the adoption of rootstock through the 1990s and up to mid-2000s would have continued in Australia. The resulting productivity gains up to mid-2000s essentially reflect the R&D effort prior to 2000 (prior to the current period of study).

However, it is highly likely that the uptake of rootstocks would have declined post-2005 without the AGWA investment. The rootstock R&D produced new information on the impact and distribution of soil borne pests highlighting they are of greater importance than was commonly believed. Further, the challenging financial situation facing growers seeking to establish new plantings or replant meant that the additional cost of rootstock had to be considered strictly on the expected benefits as against the known additional costs. Without the R&D there would not have been the analysis of the contribution that rootstocks could make, for example, to WUE or grape quality.

In the absence of AGWA funded R&D, overseas rootstock material could have been imported and planted in Australia, but selection would have been from fewer rootstock since AGWA research included breeding, identification and trialling. Expertise for this type of work typically resides outside of industry capability and in an area often characterised by market failure. That is, given the substantial R&D costs or potential for free riding on the results, an individual investor or group of investors cannot capture *enough* of the benefits to justify making the investment. Hence the market is said to fail since there is too little investment, even though the investment is overall attractive.

As Whiting (2012) concluded

> *In summary, phylloxera resistance ratings of rootstocks depend on the biotype of phylloxera used in the tests. This means resistance results from overseas are unlikely to provide a definitive result for phylloxera populations in Australia and further testing needs to occur with Australian biotypes (pg. 11).*

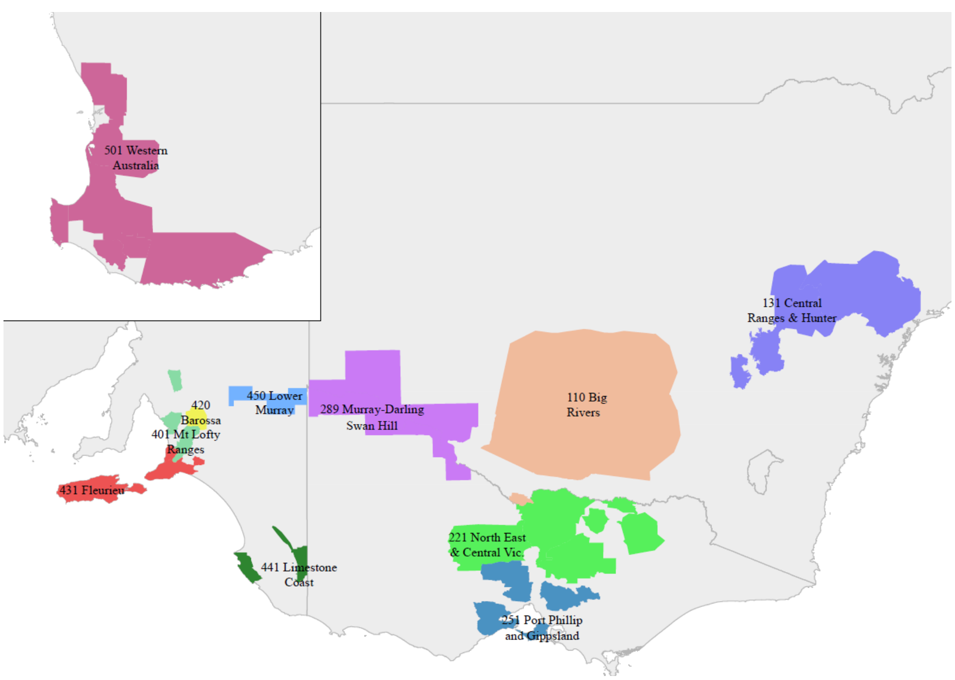
In the absence of AGWA funding, state agencies and CSIRO may have had a role in rootstock research, but this would likely have been small. Since 2000, most R&D agencies have been encouraged and/or required to have co-contributions from industry (such as through AWGA) to demonstrate the significance and relevance of the research to grape growing/wine production. Without AGWA funding, any Australian rootstock related R&D would have been slower to deliver outcomes and much smaller in scope.

Quantifying planting of rootstock and adoption of rootstock related information generated since 2000 is difficult. For this study, 2009 has been used as the starting point. The majority of the CSIRO work did not begin until 2007 and 2008, and earlier research was mainly foundation science. In addition, as a further simplification, the 2009 levels of rootstock planting across the industry are taken as a reasonable base level of what might have happened without the additional AGWA R&D since 2000.

Winegrape production areas

Across Australia, there are over 60 geographical indication (GI) regions and over 25 GI zones (grouped regions) entered in the Register of Protected Names. This analysis has used data from the main Australian zones collected by Australian Bureau of Agricultural and Resources Economics (ABARES) on wine grape plantings, production and averaged financial information at farmgate and regional level (Figure 2). Selected data from ABARES has been taken and aligned (as near as possible) to regions referred to in this report (Table 3). The ABARES regions differ from GI defined zones and regions, but in the absence of any other relevant financial information the ABARES data (and thus ABARES regions) has been used.

Figure 2: ABARES Wine grape growers survey "regions"



Source: Caboche, T, Shafron, W, Gunning-Trant, C, Lubulwa, M, Martin, P 2013, *Australian wine grapes: financial and business performance of wine grape growers 2011–12, , http://data.daff.gov.au/data/warehouse/9aas/2013/AustWineGrapesFinAndBusPerf/AustWineGrapesFinAndBusPerf_v1.0.0.pd,f accessed September 2014*

Table 3: Comparison of GI zones with ABARES survey regions

GI Region	State	ABARES region
Riverina	NSW	Big Rivers
King Valley/Rutherglen	Victoria	Central and North East Victoria
Sunraysia	Victoria	Murray Darling Swan hill
Riverland	South Australia	Lower Murray
Barrosa	South Australia	Barossa
McLaren	South Australia	Fleurieu
Coonawarra	South Australia	Limestone Coast

Benefits to growers

The main attributes sought after by growers planting rootstock include:

- resistance against phylloxera,
- resistance against various nematodes,
- production commences sooner following vineyard establishment,
- improved WUE,
- reduced potassium uptake,
- improved salt tolerance.

Phylloxera

Phylloxera resistant rootstock has been a primary focus of rootstock research and breeding for many decades in Australia and internationally. The only effective long-term management strategy for controlling phylloxera is a replanting program using vines grafted on phylloxera tolerant rootstocks. It is estimated that around 21% of the wine grapevine area in South Australia is planted to resistant rootstock.[5] Significantly, the proportion of new plantings using resistant rootstocks is high (87% in South Australian wine grapes) and increasing. However, it is unclear whether the motivation for planting rootstock over own-rooted vines is for phylloxera tolerance or other attributes of rootstock.

Research has identified grapevine rootstock breed with phylloxera resistance may not always remain resistant, given mutation and selection pressures within the phylloxera population. For example, Schwarzmann is tolerant of phylloxera strains in the King Valley, Victoria but not necessarily to strains found in Rutherglen, Victoria. Another example was observed in California, USA with a rootstock called AxR1. The rootstock, originally bred with phylloxera resistance, was observed to succumb to phylloxera in many parts of the world in the early-mid 1900s. Between 1960 and the 1980s, it was considered phylloxera resistant and widely planted. While initially the rootstock tolerated phylloxera feeding on AxR1 roots, within twenty years, mutation and selection pressures of phylloxera resulted in resistance

---

5 Phylloxera and Grape Industry Board of South Australia 2012, State Summary: Own v's Rootstock Report. Available from <http://www.phylloxera.com.au/resources/sa-winegrape-crush-survey/> [1 September 2014].

breaking down and eventual death of most vineyards planted on AxR1. In this situation, the real value of Australian phylloxera research is that it enables a faster response to future break downs in resistance than would occur otherwise.

Rootstocks are critical in limiting the adverse impacts of phylloxera, however it is difficult to attribute any one piece of research to a specific new rootstock or knowledge of rootstock performance against phylloxera. This analysis has undertaken on the basis of no attribution of phylloxera research to AGWA, except in the case of the Yarra Valley phylloxera issues.

In Victoria, phylloxera continues to spread to previously uninfested areas, e.g. Yarra Valley, and as infestation areas increase, any own-rooted vineyards will need to replanted onto rootstock.

In the Yarra Valley, grapevine phylloxera was found in one vineyard in December 2006. Subsequent detections were made in four vineyards in November – December 2008. Own-rooted vineyards in Yarra Valley total approx. 2,600ha. A Phylloxera Infested Zone (PIZ) was declared across part of Yarra Valley, capturing only about one third of vineyard area inside the PIZ. Since December 2008, no further infestations were discovered in the region until detection was announced in a vineyard near the centre of the PIZ in late March 2010.[6]

A case study, prepared in 2010 by The Phylloxera and Grape Industry Board of South Australia, on the Yarra Valley phylloxera infestation reported that:

> *Across the Yarra Valley it is estimated that less than 20% of vines are planted on rootstocks. Within the small sample of vineyard owners/managers interviewed, six out of eight reported having all their vineyards on own roots, one had 65% on rootstocks and one had 73% on rootstocks. Reasons for planting on rootstocks were mainly related to phylloxera:*
>
> *"We have a vineyard in the King Valley which prompted our decision to plant the Yarra Valley vineyards on rootstocks";*
>
> *"We were advised to plant on rootstocks [10 years ago] in case phylloxera came one day".*
>
> *Reasons for not planting on rootstocks included availability of material, cost and perceived lack of need.*[7]

Four new phylloxera detections in 2013, coupled with past detections and heightened awareness, have prompted Yarra Valley growers to replant with rootstocks.[8] In the absence of rootstocks, growers would face the expected loss of income if an outbreak occurred in their vineyard.

The reported area planted with vineyard in the Yarra Valley in 2010 was is 2,492 hectares with 15,712 tonnes crushed from the region.[9]

The 2011-12 ABARES Wine Industry survey estimated the average farm cash income for the Phillip Island and Gippsland region, including Yarra Valley, was a loss of -$97,100 per farm

---

6 Phylloxera and Grape Industry Board of SA 2010, *Phylloxera in the Yarra Valley: A case study*, PGIBSA, Adelaide.

7 *ibid*, pg. 36.

8 Yarra Valley Winegrowers Association, *pers. comm.16 October 2014.*

9 Yarra Valley Wine Growers Association *2014, Statistics for the Yarra Valley*. Available from: <http://www.wineyarravalley.com/statistics/w2/i1001407/>.[1 October 2014].

(average area of wine grapes harvested 27 ha).[10] Sales of grapes and wine contributed 67% of total farm gross revenue (grapes 39% of gross revenue and sales of wine 28%).[11]

The financial loss situation currently faced by individual growers in the Yarra Valley is compounded by the phylloxera outbreaks. For those growing own-rooted vines, there is a significant cost of replanting and income loss until vines are back in production. These costs, and also the regional economic effects (eg, tourism) have not been considered in this analysis. In addition, transport of grapes out of a phylloxera infested zone (PIZ) is prohibited which can have significant implications for the sale and processing of grapes.

Growers in phylloxera risk zone (PRZ), which are adjacent to PIZ, are able to sell and transport their grapes outside of the zone provided they meet several obligations including an annual vineyard survey (at the owner's expense) and found to be phylloxera free.

Phylloxera infestation adds business uncertainty, restricts market access and means higher compliance costs and growers with own-rooted vines face the added costs of applying management practices to protect their vines from becoming infested and (potentially) replanting their vines in the longer term.[12]

For a wine region planted on rootstock, the benefits of phylloxera protection can be expressed as:

value of avoiding future loss ($) from phylloxera

multiplied by

probability of growers investing in rootstock

multiplied by

probability of a phylloxera infestation

subtracted by

additional cost ($) of rootstock to avoid phylloxera (assuming no production or quality loss due to rootstock).

The following considerations were noted as part of the analysis:

- The relevant profitability to assess the impact of phylloxera, and its avoidance through planting rootstock, is the future net income of growers.
- Current (negative) incomes suggest that for the average grower the avoided profit loss would be small. The distribution around the average was noted.
- While the financial situation of growers is expected to improve in the medium term, a recent industry report (2013) observed that:

    "Industry (winemaking) profitability has fundamentally lowered over the last 5 years and will remain under pressure for the foreseeable future."[13] This observation is especially relevant for the Yarra Valley wine industry as around 28% of average grower gross revenue is derived from wine sales.[14] In the medium term, it was observed that "As the supply of grapes tightens—and more

---

10 ABARES 2013, Australian wine grapes: Financial and business performance of wine grape growers 2011–12, pg. 10.

11 *ibid*, pg. 19.

12 Phylloxera and Grape Industry Board of SA 2010 *Phylloxera in the Yarra Valley: A case study*, pg. 26.

13 Winemakers' Federation of Australia 2103, Actions for Industry Profitability 2014 – 2016, pg. 48.

14 ABARES 2013, *op. cit*. pg. 19.

growers make acceptable returns—winemakers will experience an increase in their cost of goods sold from the cost of grapes" [15]

- There is a lack of historical financial information for Yarra Valley vineyards which has required data from another similar region was used for this analysis.
  - A comparable cool climate wine producing region is Mudgee, NSW. The ABARES 2001-02 wine grape survey for Mudgee reports average profitability equivalent to $2,500/ha of grapes (in 2014 dollars) or $64,000 per vineyard (average area of wine grapes 26 ha) (2014 dollars, $46,000 in 2002 dollars) with profitability around 16.5% of gross revenue.[16] These data provide a benchmark comparison assuming future profitability will be similar to 2001-02, a period prior to the current winegrape price decline.
  - For this analysis, average profitability of $2,500/ha of vineyard has been used.
- The likelihood of a phylloxera outbreak will vary between vineyards depending on factors including proximity to an infested area, soil type and management practices. Uptake of rootstocks for phylloxera protection depends on perceived risk by the grower. Some growers have taken the view that the risks are small and they will manage the issue when it happens. [17] A conservative estimate could be 25% of growers estimate that there is a 20% likelihood of phylloxera impacting them and they would plant rootstock to prevent anticipated loss.
- A South Australian analysis, which was based on a representative vineyard financial model and included additional cost of rootstock, suggested a phylloxera outbreak would reduce vineyard profitability by between 20% and 50% over a 20 year period.[18]
- With the above considerations, the loss avoided by rootstocks against phylloxera infestation is $125,000 per annum (Table 4).

Table 4: Impact of rootstocks and phylloxera infestation in Yarra Valley, Victoria

Total area vineyards	a	2492	ha
Net profit	b	$2,500	/ha
Net profit loss from phylloxera	c	40%	av per annum
Probability of a grower planting rootstock to avoid loss	d	25%	
Probability of loss due to phylloxera	e	20%	in next 20 years
Expected avoided loss through using rootstock	f	$124,600	per annum

f = a*b*c*d*e

Source: IDA Economics estimates.

Nematodes

Some rootstocks have been bred with tolerance to nematodes, a soil borne pest which feeds on grapevine roots resulting in yield decline. Nematodes are commonly found in sandy soils and are present in most wine regions of South Australia and in the inland, irrigated areas in Victoria and NSW (Murray Darling, Swan Hill, Big Rivers GIs). A survey conducted across 49 vineyards in South Australia found 94% contained at least one, and up to five, species of

---

15 Winemakers' Federation of Australia 2013, *op. cit*.

16 ABARES 2013, *op. cit.,* pg. 6-9 .

17 Phylloxera and Grape Industry Board of SA 2010 *Phylloxera in the Yarra Valley: A case study*, pg. 32.

18 Schofield Robinson and EconSearch 2002, *Phylloxera in South Australia's Viticultural Regions: Report to the Phylloxera and Grape Board of South Australia*, pg. 40.

nematodes (Quader *et* al. 2000).[19] The most common and economically important nematode is root-knot nematode (*Meloidogyne* spp.).

A report from The Phylloxera and Grape Industries Board South Australia estimated lost production due to nematode infestation in Australian viticulture at approximately 7% and up to 60% loss in heavily infested vineyards.[20]

Further, Clingeleffer (2013) identified that currently available rootstocks selections are vulnerable to future losses to nematodes:

> *The commonly used rootstocks, developed in the Northern Hemisphere, where soils have lower potassium availability, tend to have high potassium uptake and high vigour leading to high juice pH, poor organic acid composition and colour under Australian conditions. Similarly, the predominant pathogenic root-knot nematodes in the Northern Hemisphere are Meloidogyne incognita and M. arenaria, whereas M. javanica is the most prevalent in Australia. Three of the six most widely used rootstocks in Australia, representing 46% of rootstock sales in 2008, are susceptible to M. javanica. The breeding parent Vitis cinerea is an excellent source of nematode resistance and is potentially also a source of phylloxera resistance.*[21]

The scientific literature suggests will continue to be a breakdown of nematode resistance in some rootstocks. Therefore, growers who have already planted rootstock may need to select an alternative rootstock with nematode resistance to avoid yield loss. AGWA R&D projects have provided information to assist growers and nurseries select the best nematode resistant rootstocks.

The estimated value gained from planting nematode resistant rootstock is presented in Table 5. Within this analysis, use of rootstocks has been estimated at reducing yield loss by 10%, although this estimate is considered conservative by subject matter experts. Several scenarios with greater yield loss savings are explored in the sensitivity analysis (Table 15).

This analysis includes purchased grapes but not the value of grapes used in estate winemaking, given the absence of data. In some regions, this includes several significant producers (eg: Banrock Station and Kingston Estate in the Lower Murray/Riverland) who have large plantings of nematode resistant rootstocks but yield data is not captured. By estimating the tonnes via any other means could lead to significant over-estimation and was not attempted.

Table 5: Estimated savings from nematode resistance: By ABARES "region": Average per farm and per ha: 2011-12

---

[19] Quader M, Riley IT, Walker GE 2002, Damage threshold of Meloidogyne incognita for the establishment of grapevines, *International Journal of Nematology*, 12, pgs. 125-30

[20] Phylloxera Board and Grape Industry Board of South Australia 2014, Research-Nematodes. Available from <http://www.phylloxera.com.au> [1 September 2014].

[21] Clingeleffer, P. 2013, Rootstocks to meet future challenges of the Australian wine industry, GWRDC Project Number: CSP 1101. Available from <http://research.agwa.net.au/completed_projects/rootstocks-to-meet-future-challenges-of-the-australian-wine-industry/> [1 September 2014].

	Average per farm					
	Grape production	Gross income: wine grapes, table grapes and DVF	Av value/t	Estimated yield loss	Value of estimated yield loss	Value gained (avoided loss) per harvested ha
ABARES region	(a)	(a)		5%		
	t	$	$/t	t	$	$/ha
Big Rivers	837	$237,790	$284	42	$11,900	$177.61
Central and North East Victoria	393	$120,190	$306			
Murray Darling Swan hill	1183	$334,100	$282	59	$16,700	$309
Lower Murray	905	$257,240	$284	45	$12,900	$339
Barossa	296	$358,930	$1,213	15	$17,900	$426
Fleurieu	422	$350,510	$831	21	$17,500	$365
Limestone Coast	656	$504,500	$769	33	$25,200	$300

Source: IDA Economics estimates using ABARES 2013 data

Yields

Some rootstocks have been bred specifically to produce higher yields, while other have attributes (eg, nematode resistance) which allow them to outperform own-rooted vines.

The impact of rootstocks on yield was explored by Whiting (2012) and he concluded:

> *It is difficult to quantify a direct rootstock effect on yield, due to the multiple contributors to yield. In most cases, increased yield is due to increased growth and the ability to retain more buds per vine (e.g. on Ramsey and Dog Ridge). Where soil pests exist, grafted rootstocks out yield ungrafted V. vinifera vines. Where there is abiotic stress alone, rootstocks do not always yield better than ungrafted vines. (pg.21).*

Attribution of yield gains to rootstocks across the wine industry is complicated given there are many factors at work aside from the rootstock; scion clone, vineyard management, irrigation.

Clingeleffer (1994) noted:

> *The significant improvement in yield of sultana can be attributed to the use of high vigour, nematode resistant rootstocks, improved clones (eg. H5), lighter pruning on larger trellises and adoption of improved irrigation management practices.*[22]

While improved vineyard management is known to increase yield across the wine industry, these gains have been tempered by some wineries imposing yield caps resulting in intentional reduction of yield or some grapes remaining unharvested (thus data not captured).

In summary, it is difficult to generalise as to the effects of rootstock on yield and no quantitative estimate has been made.

Reducing the lead time to production

Researchers and growers report planting strong, healthy rootstock grafted vines can bring production forward by around a year compared with own-rooted vines. However, data on this aspect is not widely published. For those planting rootstocks, the reduced lead time nursery is equivalent to an additional year of net income from grape production, earned up front.

For this analysis, the financial benefit of bringing production forward by a year has been estimated using Farm Cash Income, prepared by ABARES (2011-12). While a relatively

---

22 Clingeleffer, PR 1994, *Changing technology of dried fruit production for yield, quality and profitability increases*. In: McMichael, P.A. and Scholefield, P.B., editors. Gaining the competitive edge: Proceedings of the Second Horticultural Industry Technical Conference. Wentworth, N.S.W. Marleston, S. Aust.: Winetitles: 44-47

coarse measure, this data comes closest to reflecting the net value of production per hectare. For this calculation, Farm Cash Income = gross income – operating expenditure, where:

Gross Income = on farm (grapes and wine sales plus other horticulture) and off farm income sources

Operating expenditure = services, materials, labour and interest.

Calculated Farm Cash Income, across the identified regions, ranges from $0 to $3,200/ha (2011-12) (Table 6).

Another approach to measure financial benefit is 'gross margin', which can be defined as:

Gross margin = gross income – variable costs

Variable costs have been estimated at 30%, implying a gross margin ranging between $2000/ha and $6000/ha depending upon the region (Table 6).

The gross margin approach has been adopted in this analysis since the fixed costs of production are much the same for own-rooted vines as for rootstock (noting that the additional costs of planning rootstock are accounted for separately in the analysis). In the case of NE Victoria the farm cash income approach has been used as variable costs as a percentage of gross variable costs appear to be lower than in the other growing areas.

Table 6: Selected physical and financial data: Wine grape farms 2011-12 (Average per farm)

ABARES region	Area harvested	Gross income: wine grapes, table grapes and DVF	Farm cash income (all sources, net of cash costs)	Gross income grapes/ha harvested	Farm cash income/ha	Gross income grapes sales less variable cash costs/ha
						30%
	ha	$	$	$/ha	$/ha	$/ha
Big Rivers	67	$237,790	-$1,330	$3,549	-$20	$2,484
Central and North East Victoria	41	$120,190	$131,760	$2,931	$3,214	$3,214
Murray Darling Swan hill	54	$334,100	$122,830	$6,187	$2,275	$4,331
Lower Murray	38	$257,240	$97,350	$6,769	$2,562	$4,739
Barossa	42	$358,930	$104,710	$8,546	$2,493	$5,982
Fleurieu	48	$350,510	$91,840	$7,302	$1,913	$5,112
Limestone Coast	84	$504,500	$208,100	$6,006	$2,477	$4,204

Source: ABARES 2013, and IDA Economics estimates.

Water Use Efficiency (WUE)

High WUE is largely a function of reduced water use rather than a net increase in yield.

While water savings vary widely depending on site and irrigation management, in some trials, water savings of up to 2.5ML/ha (~50%) have been achieved whilst maintaining yields[23], based on irrigation rates of 4.5 – 5.5ML/ha.

For this analysis, a more conservative water saving estimate (20%) has been used, given the variation between years in water requirements and differences between regions. The implications of alternative estimates of the water saving gains are examined in the sensitivity analysis (Table 15).

The trading price of water is influenced by local supply and demand issues and seasonal conditions. The value of savings with the use of rootstocks is estimated to range between $21 and $177/ha (

23 Clingeleffer, P. pers comm. 14 October 2014.

Table 7), with the higher saving reflecting the significantly higher water use/ha in the Big Rivers, NW Victoria and the Lower Murray region.

Table 7: WUE: Water use and estimated water savings 2014

Region	Water use: Wine grapes 2011-12 (a)	Grape area 2011-12(a)	Irrigation use (b)	Savings from using rootstock without yield or quality penalty		Indicative price of water (d)			Value of savings (f)
	ML	ha	Ml/ha	% (c)	Ml/ha	Permanent entitlement type	$/ML	Annual cost $/Ml (e)	$/ha
Big Rivers	118,260	28,991	4.1	20%	0.82	NSW Murray High Security	$2,000	$200	$163
Central and North East Victoria	4,846	7,529	0.6	20%	0.13	Vic Murray High Reliability – Zone 7	$1,600	$160	$21
North West Victoria	65,274	11,777	5.5	20%	1.11	Vic Murray High Reliability – Zone 7	$1,600	$160	$177
Lower Murray	111,441	20,732	5.4	20%	1.08	Vic Murray Low Reliability – Zone 7	$1,600	$160	$172
Barossa	8,313	12,982	0.6	20%	0.13	SA Irrigation Entitlement	$1,850	$185	$24
Fleurieu	21,506	13,358	1.6	20%	0.32	SA Irrigation Entitlement	$1,850	$185	$60
Limestone Coast	19,868	15,165	1.3	20%	0.26	SA Irrigation Entitlement	$1,850	$185	$48
Other regions (g)			2.8	20%	0.57			$160	$91
Table grapes		8,700	5.5	20%	1.11	Vic Murray High Reliability – Zone 7	$1,600	$160	$177
DVF		1,500	5.5	20%	1.11	Vic Murray High Reliability – Zone 7	$1,600	$160	$177

(a) ABS, 329.0.55.002 - Vineyards Estimates, Australia, 2011-12
(b) Calculation: Water
(c) Peter Cliffelinger, pers comm. Conservative estimate
(d) Ruralco water, http://www.ruralcowater.com.au, Accessed 21 August 2014
(e) Annualised cost at net 10% interest rate (excludes any capital gain); excludes delivery charges (if applicable); indicative as variation between regions and over time.
(f) Value of savings = Savings % * (Ml/ha * Annual price of water/Ml)
(g) Average above regions, excl. Big Rivers, NW Victoria and Lower Murray

Source: IDA estimates

Drought tolerance

Drought tolerance is defined as the ability to survive reduced water availability and may occur through several mechanisms. However it is difficult to determine suitable markers for drought tolerance (Clingeleffer, 2007; Clingeleffer and Smith, 2011) and research in this area continues. That said, rootstocks played a key role enabling growers to maintain yield during the extended drought period and in reducing grower costs for purchase of limited water that was available.

No quantitative estimate made.

Soil salinity

When excessive levels of sodium chloride (NaCl) accumulate in the soil, it can result in reduced vine vigour, yield decline and elevated NaCl levels in the grapes. In this situation, rootstock selection is particularly important, especially under reduced irrigation regimes and/or use of highly saline irrigation water. Food standards Australian & New Zealand set a maximum limit of salt (set as Cl) in wine within the Food Standards Code. In some cases, wine below the upper limit set by the Code can have a noticeable 'salty' taste which has significant negative impact on wine quality.

There are a range of rootstocks that demonstrate good capacity of Cl- and Na+ exclusion.[24] Salt tolerance operates mostly through rootstock vigour and capacity for roots to exclude salt.

Stevens (2012) identified that salt excluding rootstocks planted in saline soils can reduce NaCl uptake by vines, reduce salt levels in grapes, and hence in wine.[25] He observed 24 year-old rootstock grafted Chardonnay vines growing on deep sands had yields matching or in excess of own rooted vines planted nearby. Compared with own-rooted vines, levels of sodium and chloride in the grape juice were reduced by half in vines on rootstock including K51-32, SO4, 5C Teleki, and Fercal. Yields were maintained.

Post-2000 GWRDC R&D by AGWA (since 2000) has identified salt tolerant rootstocks (eg,1103 Paulsen and 140 Ruggeri) and developed strategies to improve management of rootstocks.

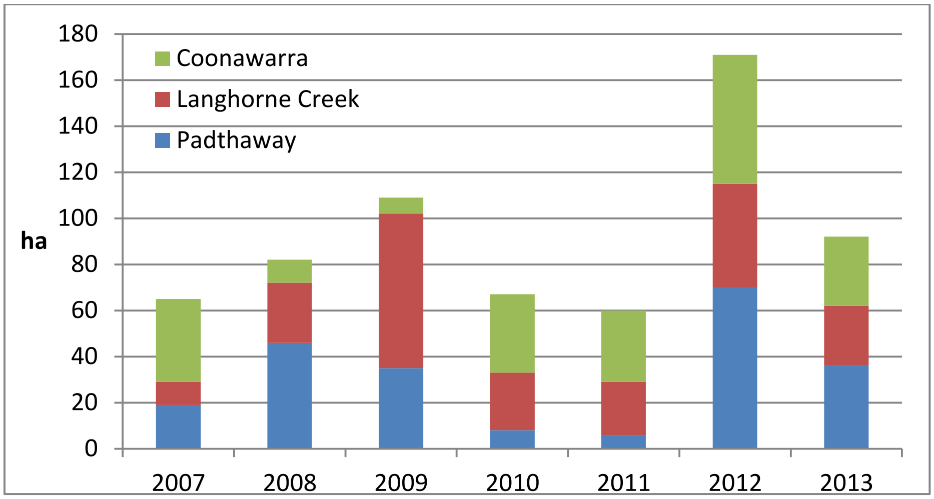
---

24 Walker, R 2010 Managing salinity in the vineyard, *Growing Winegrapes 2010 Conference*, pgs. 2-3.

25 Stevens, R. and T Pitt 2012 *Guidelines for Managing Soil Salinity in Groundwater Irrigated Vineyards*, The National Program for Sustainable Irrigation, NPSI Project 06-12-2, pg.10.

Salt tolerance has been cited as one of the factors favouring rootstock selection in recent new plantings in Padthaway, Coonawarra, Langhorne Creek (South Australia) (Figure 3). Rootstock tolerance to salinity is estimated to contribute 40% of the decision-making for Padthaway, 30% of the decision-making for Langhorne Creek and 20% of the decision-making for Coonawarra.[26] In 2013, around 15,500 hectares were planted across the three regions.

Figure 3: New plantings of winegrapes (including top-working and replacements): selected regions South Australia 2007-13



Source: Phylloxera and Grape Industry Board of SA, SA Winegrape Crush Survey, various years http://www.phylloxera.com.au/resources/sa-winegrape-crush-survey/, accessed October 2014.

Given the complexity in accurately calculating the financial benefit to industry from using salt tolerant rootstocks, no quantitative estimate of the benefits has been made.

Potassium

In many wine regions of Australia, particularly warmer climate wine growing regions, high potassium in harvested grapes is common necessitating pH adjustment during winemaking. As a result tartaric acid addition is a common practice during the winemaking process in many Australian wineries.[27]

Since 2000, there has been an emphasis on improving wine composition through R&D on rootstocks. The recently developed low to medium vigour grapevine rootstocks, Merbein 5489, Merbein 5512 and Merbein 6262, have been commercialised and released to industry. These three Merbein rootstocks take up less potassium resulting in lower grape juice pH and less pH adjustment in the winery compared with other rootstocks.

Estimated cost saving to winemakers are detailed below:

- 700 litres of juice per tonne of grapes crushed[28]
- 4g of tartaric acid added per litre juice (estimated average) and $4.30/kg tartaric acid[29] - equivalent to 2.8 kg tartaric acid/tonne grapes crushed
- Approx. $12/tonne grapes crushed (noting this figure would vary between regions)

---

26 Walker, R., *pers. comm*, 11 September 2014

27 Thomas, M. and M. Treeby 2004, *Managing grape berry potassium (K+) accumulation to enhance wine quality*, GWRDC Project CSP 00/4.

28 ABS 2013, *Australian Wine and Grape Industry, 2012-13*, Cat. No 1329.0. Australia: Wine produced (1,231ML)/Grapes crushed (1,748,363t).

29 Australian Tartaric Products Pty Ltd, pers. comm, 16 October 2014.

Estimated benefits by region, using production data from 2011-12, are shown In Table 8, The cost savings are estimated assuming the rate of tartaric acid addition is the same across all regions and the excessive potassium problem is fully overcome by planting relevant rootstocks.

Table 8: Estimated cost savings to winemakers with reduced potassium level grapes

ABARES region	Area	Production	Yield	Potential cost saving	Est cost saving realised pre adoption
	ha	kt	t/ha	$/ha	$/ha
Big Rivers	21,188	249	11.8	$141	$71
Central and North East Victoria	7,315	44	6.0	$72	$36
Murray Darling Swan Hill	18,630	380	20.4	$245	$122
Lower Murray	20,495	436	21.3	$255	$128
Barossa	12,342	74	6.0	$72	$36
Fleurieu	13,224	99	7.5	$90	$45
Limestone Coast	15,037	107	7.1	$85	$43

Source: IDA Economics estimates

For this analysis, of all new rootstock plantings across Australia, 5% planted are those with lower potassium uptake attributes and 50% of the excessive potassium issues are resolved by planting rootstock. And there is no financial downside to using the lower potassium uptake rootstocks.

Additional costs of rootstock

Grapevines purchased at the nursery vary from about $4.80/vine for rootstock grafted compared to about $1.60/vine for own-rooted vines. These figures have been used in this analysis. It is worth noting that private growers may be able to grow their own vines (own-rooted or grafted) but numbers are likely to be small in any one season.

Summary of benefits

The estimated values of improved rootstocks, where quantitative estimates have been made, are presented in Table 9. The other known benefits which have not been quantified, include:

- Phylloxera resistance,
- Drought tolerance,
- Salinity tolerance,
- Reduced potassium uptake.

Table 9: Estimated annual benefits from using improved rootstock: By type of benefit and by ABARES region

ABARES region	Bringing production forward	Phylloxera (Yarra Valley only)	Avoiding nematode loss	WUE (b)	Lower potassium	Total
	One off			Annual for life of vine		
	$/ha	$/ha	$/ha rootstock	$/ha rootstock	$/ha rootstock	
Big Rivers	$2,484		$178	$163	$4	$344
Central and North East Victoria	$3,214		$0	$21	$2	$22
Murray Darling Swan hill	$4,331		$309	$177	$6	$493
Lower Murray	$4,739		$339	$172	$6	$518
Barossa	$5,982		$426	$24	$2	$452
Fleurieu	$5,112		$365	$60	$2	$426
Limestone Coast	$4,204		$300	$48	$2	$351
Yarra Valley		$50				$50
Other regions	$4,597		$0	$91	$0	$91
Table grapes (a)	$4,331		$309	$177	$0	$487
DVF (a)	$4,331		$309	$177	$0	$487

(a) The estimated benefits/ha for Table grapes and DVF estimated to be the same as those for Sunraysia more generally

(b) Regional WUE based on respective state average water use and state average water prices. This approach is recognised as simplistic but a pragmatic one given limited data.

Source: IDA Economics estimates

Adoption

Growers planting rootstocks in new vineyard (ie not previously planted to rootstock) can expect to reap the full benefits including bringing production forward, avoided yield losses (from reduced nematode impact) and improved WUE. However, to achieve these benefits management may need to differ compared with own-rooted vines.

Growers replanting vineyard previously planted on rootstock are unlikely to see the same level of gains since any gain from any alternative rootstock would be smaller compared with own-rooted vines. Firstly, the grower does not gain the benefit of bringing production forward. Secondly, the extent of the annual improvement is the gain from alternative rootstock compared with the existing rootstocks (and not own-rooted vines). In this analysis it is estimated that growers who replace old rootstocks with new rootstock would gain half the measured benefit compared with a conversion from own-rooted vines to rootstock.

Adoption costs

To achieve benefits from rootstocks, growers incur an establishment cost of an additional $3.20 per vine compared with own-rooted vines. A grower who replants on rootstock does not incur the additional cost since they had already planted rootstock.

Once planted, rootstocks may require additional effort in vineyard management rather than additional cash costs.

Adoption levels

Approach

The benefits to growers can be expected to have increased the level of adoption of rootstock in new plantings and in replanting.

However, often when figures for adoption are quoted, only the *average level of rootstock use* is detailed. That is, the share of the total (industry) vineyard that is planted on rootstock. The level of adoption is often viewed as low, particularly in South Australia. A low level of adoption implies that the benefits from the R&D are small and can lead to judgments that something should be done to lift the level of adoption.

However, this measure takes only limited account of the adoption at the margin (proportion of rootstock in annual plantings) which, in a perennial crop (vineyard lifespan is often 30 years plus) means that it takes a long time for a lift in the average importance of rootstock. Certainly if the returns from rootstock were extraordinary there would be a higher rate of annual replacement and a faster increase in the average importance of rootstock. However, in reality that is not the case.

Second there is the issue of industry expansion and new plantings. If the industry, particularly for wine grapes, was expanding rapidly, and rootstock offered significant gains, then again the average rate of rootstock adoption would rise. However, neither has been the case in much of the industry in recent years. In many wine regions, the perceived risk of phylloxera and nematodes are insufficient relative to anticipated losses in yield to justify the additional cost of planting rootstock. Furthermore, issues of drought tolerance have become an important driver for adoption in the warmer irrigated regions, including many in South Australia.

Third, the average measure ignores the planting of improved rootstock when vines already on rootstock are replaced. The potentially significant gains for growers from using improved rootstock are not included. This has been a significant aspect of the AGWA projects. An indication of the importance of adoption of improved rootstocks can be gleaned from the change in the types of rootstocks used over time.

These issues mean that three aspects of rootstock adoption need to be recognised:

- using rootstock instead of own-rooted vines — adoption of rootstocks in replanting

- using rootstock in new production areas (industry growth) — adoption in new plantings
- using improved rootstocks to replace existing use of rootstock — adoption of improved rootstocks.

Adoption of rootstocks

The industry data suggest that adoption of rootstocks since 2009 has increased (Table 10), but only at a low rate, equivalent to less than 1% per year in most regions. The overall level of adoption is about 21% in South Australia. Rates of adoption are high in areas where phylloxera and nematodes are major risk factors, such as the Sunraysia, Lower Murray, Riverina and North east Victoria, but low in many other areas including South Australia.

Table 10: Rootstock adoption 2009 and 2013: Derived from area on rootstocks

Area		2009	2013	Percentage point change 2009-13	Annual percentage point change 2009-13	Annual rate of change (compound)
		%	%	%	%	%
SA statewide	(a)	20	20.8	0.8%	0.2%	1.0%
Riverina	(b)	15	17.0	2.0%	0.5%	3.2%
King/Rutherglen	(c)	100	100.0	0.0%	0.0%	0.0%
Sunraysia	(c)	68	68.1	0.1%	0.0%	0.04%
Lower murray	(a)	40	43.1	3.1%	0.8%	1.9%
Barrosa	(a)	20	23.4	3.4%	0.8%	4.0%
McLaren	(a)	8	9.9	1.9%	0.5%	5.5%
Coonawarra	(a)	2	3.3	1.3%	0.3%	13.3%
Other areas	(d)		5.0		0.5%	

(a) Data from Phylloxera and Grape Industry Board of South Australia
(b) NSW Wine industry Association; 2009 estimated IDA Economics
(c) Data from Sunrise 21 (Wine grape varieties)
(d) Industry estimate

Source: Walker, R, Clingeleffer, P and Smith, B 2013, *Rootstock use and major needs – Australia*, ASEV and IDA Economics estimates

Both the 2009 and 2013 levels of adoption differ markedly between regions. These differences reflect issues such as phylloxera presence (eg: King Valley and Rutherglen, Vic), the presence of nematodes (Sunraysia, Vic and Riverland, SA), no phylloxera/few nematodes (eg: McLaren Vale and Coonawarra) and the higher relative importance of table grapes and dried vine fruits (Sunraysia, Vic). Adoption of rootstocks range from 100% (areas with phylloxera) to 3.3% (no phylloxera or nematode issues). Increases in the proportion of rootstocks may also arise as older ungrafted vines are removed whilst profitability remains low.

Further, some care is needed in interpreting the 'regional analysis/. For example, the Central and North East Victoria 'ABARES Region' includes several other industry areas regions where the use of rootstocks is not 100%, and in some areas very much lower.

The increases in the adoption of rootstock in the areas outlined in Table 10 since 2009 have been positive, at annual average percentage increases ranging between 0.2% and 0.8%. In the broad context of adoption across agriculture generally these increases seem 'low', but it needs to be recognised that during the rapid expansion phase of the industry, many vineyards were planted on own roots in greenfield sites, partly due to the shortage of grafted vines. These sites will require rootstocks when redeveloped.

Equally, choosing to use rootstock over own-rooted vines has to be seen in the context of limited new plantings and replacement replanting occurring within the typical vineyard life of 30 plus years ie: low levels of annual replacement unless there are overwhelming market or production changes. Thus the 'average' importance of rootstock across the industry will invariably be slow to change.

Of more importance is the estimated current proportion of rootstock plantings in all new plantings and replantings. In South Australia this has been estimated at 87% (2011)[30] and this trend it likely to continue given the evidence of nematode problems.

If this rate of increased rootstock planting were to continue the average importance of rootstock across South Australia would approach by 60% 2025 (assuming 3% replacement of vines each year to enable continuous replacement of vineyard over a 30 year life span). On more conservative analysis (for example, 50% of plantings are on rootstock) the share of rootstock would be around 43% by 2025. Some growers may replant less frequently which would reduce the rate of adoption.

However, using the most recent data (2009-13) showing annual growth in the average rootstock share of 0.2% (South Australia, Table 10), the share of rootstock in the total area would approach 25% by 2025 up from 20.8% in 2013.

New plantings: industry growth and rootstock share

Wine industry growth has been small over the last decade, given the financial challenges facing winemakers and growers. Nonetheless, the overall low growth masks within industry developments. Specifically, the continuing expansion and new plantings of some wine varieties within some regions. This expansion offers an opportunity for additional plantings on rootstock but the economics have to favour using rootstocks.

Industry discussions suggest that additional new plantings in Tasmania and other cool climate wine growing areas are not using rootstock as the higher planting costs are not justified due to lower pest and disease risk. In Western Australia there is little use of rootstock for wine grape production. In other areas such as McLaren Vale and the Barossa, potential WUE gains are suggested as outweighing the additional planting costs.

In the table grape and dried vine fruits industries virtually all vines are planted on rootstock and recent expansion of these industries involved further rootstock plantings. Nationally, the area planted to table grapes has increased by 1500 ha to 8700 ha in the last 5 years.[31]

Adoption of improved rootstocks in vineyards already on rootstock

The average level of adoption does not capture growers planting improved rootstock to replace vines already on rootstock. In this situation, it is worth noting the following:

- Much of the AGWA R&D investment has focussed on improved rootstock to replace existing rootstocks and, in the case of soil salinity issues, to replace own rooted vines (which take up more sodium chloride). This R&D has offered growers a wider selection of rootstocks with additional attributes and information on productivity gains to enable better rootstock (and scion) selection for specific vineyard sites,
- Pest and disease issues, particularly more aggressive nematodes, mean that using new rootstocks instead of existing rootstocks is of key importance to ensure production is maintained,
- Older vineyards, planted several decades ago, on 'traditional' rootstock (eg, Ramsay) are now entering a period of their life where vineyard renewal has been or will soon be called for.

The change in the mix of rootstocks sold over the last decade highlights this issue. While the total sales of rootstock cuttings have increased (20% over the decade, reflecting in part the minimal overall industry growth noted above) the relative importance of 1103 Paulsen, 140 Ruggeri and 101-14 have increased and the older rootstocks, Ramsay in particular, have declined (Table 11).

---

30 Phylloxera and Grape Industry Board of South Australia 2014, http://www.phylloxera.com.au/resources/rootstocks/ , accessed 15 August 2014.

31 *The Vine*, 2014, Analysis of grape industries key for redevelopment and investment, April/June, pg. 23. www.australiangrapes.com.au/__data/assets/pdf.../2014_APR-JUN.pdf, accessed 16 September 2014.

Table 11: Rootstock cuttings supplied by state Vine Improvement Groups

Rootstock	1989-1993	2007-2011
Ramsay	54.3	15.2
Schwarzmann	17.6	2.3
K51-40	5.4	0.0
K51-32	2.6	<1.0
5BBKober/5A Teleki	7.0	32.1
140 Ruggeri	1.6	16.2
101-14	1.2	10.2
Dog Ridge	1.2	1.7
SO4	1.9	<1.0
99 Richter	3.2	<1.0
5CTeleki	1.7	1.4
1103 Paulsen	<1.0	43.0
110 Richter	<1.0	6.6
Other	2.3	1.3
Mean number of cuttings per year	2,269,400	2,689,292

Source: Whiting, J. 2012, *Rootstock breeding and associated R&D in the viticulture and wine industry* (GWR 1009), Australian Grape and Wine Authority, Adelaide pg 7.

The past and the future

In most cases, the same factors that have impacted on planting of rootstocks in recent years are likely to continue in the medium term (next 5 years).

- Phylloxera continues to be important and will become more relevant for some growers.
- Nematodes are an increasingly important issue as replacement plantings will need to focus on profiling the nematodes status of (new and replacement) sites and selecting rootstock accordingly.
- WUE is of greater importance now, given experiences during the 'millennium drought', especially in South Australian growing regions. WUE will continue to remain important as climate variability impacts availability of irrigation water. Similarly the case for drought tolerance.
- Consumer preferences will mean that wine with elevated salt levels will be rejected. In salt affected areas, demand for salt tolerant rootstocks will increase.
- Cost pressures within wine making will continue to see demand for vines that exclude excessive potassium, thus reducing pH levels in grapes and avoiding the need to take corrective actions in winemaking.
- Increased grower confidence in successful management of rootstock (including initial rootstock and scion selection) will have a cumulative effect –growers with understanding of rootstock management will encourage other growers to use rootstock resulting in an increased the level of rootstock use.
- All table grapes are planted on rootstock and market opportunities for table grapes continue to increase resulting in an anticipated increase in planted area. Recent industry observations indicate:

  Preliminary figures indicate that table grape plantings in the Lower Murray Darling region (VIC and NSW) now represent at least 30% of all grape plantings (in that region), having increased by more than 1,500 hectares in the last three years to a total of 8,700ha.

  Opening of export markets has fuelled confidence and redevelopment. Added to the rapid increase in planted area, there have also been significant changes in varieties, irrigation and rootstocks in the last decade, in response to fluctuating conditions *(drought/low water allocations, unstable temporary water prices, a high Australian dollar).*[32]

With new markets opening, plantings are expected to increase with a shift to better performing varieties.[33]

- In dried vine fruit, there has been a significant shift to high yielding varieties established on fully mechanized production systems.
- There are two main barriers to planting of rootstocks in the wine grape industry.
    - 1) During the large industry expansion of the late 90s and early 2000s, some dubious vine material was planted. Several years later, many insidious diseases, including virus and trunk disease, are causing reduced production and vine death. Infested rootstock material has been implicated and growers who have had grafted vines fail are often reluctant to plant again using grafted vines.
    - 2) Winemaker perception of grafted vines is often associated with excessive vine vigour or lower quality grapes. This perception most likely arose from over application of water and fertiliser in the early days of rootstock assessment resulting in overly vigorous vines with shaded, low quality fruit. Better understanding of rootstocks has largely addressed the vineyard management issue, but the perception still remains.

- The planted area of vineyard in the Australian wine industry is not expected to increase substantially in the medium term. The financial situation of growers is expected to improve in the medium term albeit noting that a recent industry report (2013) observed that:
    - "Industry (winemaking) profitability has fundamentally lowered over the last 5 years and will remain under pressure for the foreseeable futureThe slow improvement in winemaking profitability would be in part due to restructuring the grape growing industry and a consequential rise in the cost of goods sold (which includes grapes). The Winemakers' Federation of Australia reports "As the supply of grapes tightens—and more growers make acceptable returns—winemakers will experience an increase in their cost of goods sold from the cost of grapes" [34]

- To address the current market situation some have suggested that the area needs to drop by around 20%.
    - *"If you said 'readjust the Australian wine industry overnight', you'd probably want to get rid of 15 per cent of the acreage," Mr Tyrrell said. "That would push the price of grapes up and make it a more profitable industry. But it would push retail prices up, too."*[35]

Considered together, the factors below can be expected to at least maintain the recent rates of growth in the rootstock share of the industry vineyard, and possibly increase it.

---

32 *The Vine*, 2014, Analysis of grape industries key for redevelopment and investment, April/June, pg. 23. www.australiangrapes.com.au/__data/assets/pdf.../2014_APR-JUN.pdf, accessed 16 September 2014.

33 Australian Table Grape investment Strategic Plan, 2012-17, pg 8

34 *ibid*.

35 Bleby, M 2014, Good fruit and vegetables 2014, Cut grape output: Tyrrell, http://www.goodfruitandvegetables.com.au/news/nationalrural/agribusiness/general-news/cut-grape-output-tyrrell/2709696.aspx, accessed 8 October 2014.

- R&D identifying and demonstrating that rootstocks have attributes of benefit to growers, In particular, drought tolerance, salt tolerance and WUE but also fruit quality which is often a concern to growers and winemakers
- Recognition of the spread of phylloxera
- Nematode population build up and the appearance of more aggressive strains
- Better understanding and application of the management required to achieve the types and level of gains demonstrated in the R&D
- Promotion of rootstock advantages by research agencies, consultants, vine improvements societies and nurseries

Improvements in grafting practices and success rates to produce cost effective grafted vines, R&D on rootstocks can be a drawn out process given the initial lab work, field work required to trial rootstock and commercialisation of new rootstocks for public use. The comparison between rootstock sales in 2009 and 2013 provides reasonable guide on recent adoption levels. However, in assessing future adoption levels an understanding of the underlying drivers of past, current and future adoption are required.

Quantifying adoption

Quantifying the value to growers from the AGWA R&D investment requires quantification of adoption to date and in the future. The latter is particularly important given the lead times in completing the R&D (especially in field trials work), the adoption issues noted above and the longevity of the R&D benefits given that vineyard lifespan may be 30 years or more.

The approach to quantification and the key estimates are as follows.

- The area of grapes in each ‘region’ has been sourced from the ABARES survey data (Australian wine grapes: financial and business performance of wine grape growers 2011–12).
- Areas for table grapes and dried vine fruits have been added to provide an overall regional area and production total.

The adoption time frame

The adoption time frame is 2009 to 2040, reflecting the lead time in R&D, commercialisation of rootstock, adoption by growers and the longevity of vines (before eventual replacement).

Adoption of rootstock is segmented into:

- Replanting rootstocks in areas previously planted on own-rooted vines.
- Planting rootstocks in previously unplanted area.
- Replacing existing areas planted on rootstock.

Replanting rootstocks in areas previously planted to own-rooted vines is estimated to continue at the same average rate as in recent years. That is, less than 1% in the regions of interest. This may well be conservative as it implies minimal adoption by growers who have traditionally used own-rooted vines.

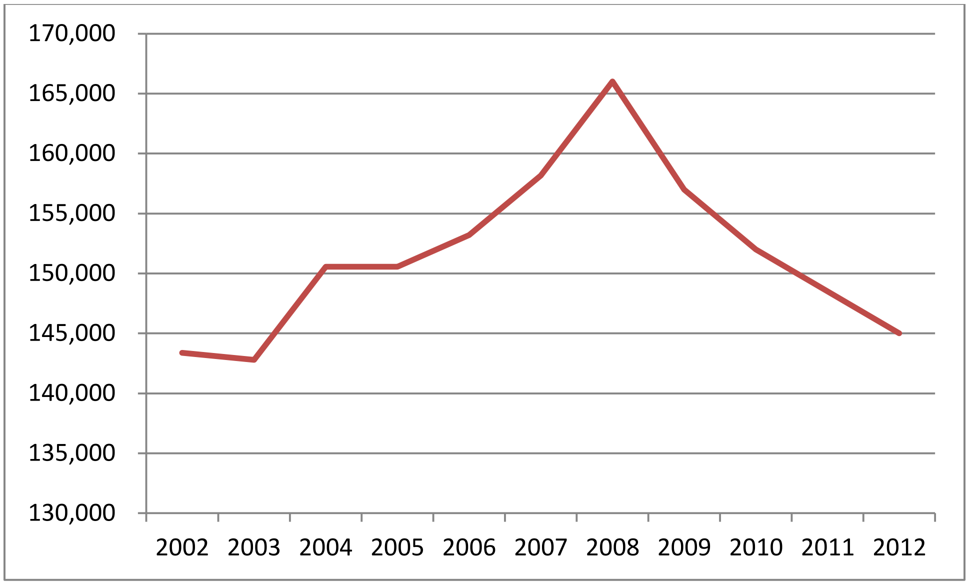
Rootstock planting in new vineyards.

The bearing area of grapes rose and then fell during the 2002-12 period (

Figure 4). As an average, the area grew by 2% between 2002-2004 and 2010-2012, implying an annual growth rate of 0.25% per annum. Removal of vines is still being discussed within the wine industry so total plantings may have fallen below the 2012 figure.

However, this only reflects net vineyard area growth (eg: vineyard replacement) while the new plantings, gross vineyard area, is very important to understand. From ABS data, gross area is estimated to have grown by 0.5% per annum. In the next decade, it is unlikely that any new areas planted to winegrapes would exceed the growth rate of 0.5% per annum. A change in national or world wine production may see growth increase beyond the next ten years, but is very difficult to predict.

Figure 4: Area of wine grapes: Bearing area: 2002 to 2012 (ha)



Source: ABS, Vineyard estimates, various years

Rootstock replanting in existing vineyards.

There is little industry data to allow estimation of the level of rootstock replanted - that is where rootstock is used to replace existing rootstock. However, it is likely to be significant, as noted above.

The future demand for 'improved' rootstock (rootstocks with identified superior characteristics to address certain issues and which can be attributed to the work from the AGWA projects) to replace existing rootstock plantings is estimated by considering three factors: the current area of rootstock, the age at which it is replanted and the proportion of the area to be replanted with improved rootstock.

- A vineyard lifespan of 30 years has been assumed, although the variation around this period is likely to be significant The longer the replant interval, the lower the replanting rate of rootstocks in any one year.
- The replant area required to maintain the current level of rootstock plantings, assuming a 30 year economic rootstock life has been calculated for several regions (Table 10). For example, in the Barossa, the total area of vines is 12,342 ha with 23% planted on rootstock. This implies an area of rootstock of 2,888ha. On the basis of a 30 year lifespan, about 96 ha of rootstock plantings need to be replaced each year, equivalent to 3%.
- The proportion of replant rootstock planted to 'improved rootstock is estimated at 50%. While the rootstocks 1103 Paulsen, 140 Ruggeri and 101-14 made up 70% of total rootstock cuttings sold mainly to nurseries 2007-11, the other rootstocks remain of significant importance. As it is probable that the share held by the former rootstocks will increase in coming years and the new rootstocks developed will gain a share of the market, an 80% total share held by improved rootstocks is a reasonable estimate.

Table grapes and dried vine fruits

Table grape and dried vine fruits growers have made extensive use of rootstock both for pest issues management and yield benefits. Coupled with 'good management' growers have been able to harness the vigor of rootstocks.

For table grapes and dried vine fruits:

- 100% of the existing plantings are estimated to be planted on rootstock
- New vineyard developments are estimated at 1% per annum.

All replanting and new developments are estimated to be on improved rootstock. The R&D funded by AGWA has generally focused on wine attributes (low potassium, low berry size, moderate vigour) which may not be as applicable to table grapes need (potassium not an issue, large berry size, high vigour to provide canopy shading), although other attributes are common (nematode and phylloxera resistance). The dried fruits industry is funding, in a small way, new rootstock development by CSIRO funded through Horticulture Australia Limited targeting the pest and disease issues, water use efficiency and yield.

Summary

Since 2005, the estimated area of grapes planted onto rootstock is around 1800 ha (Table 12) per annum. Assuming no industry growth, 1800 ha would be the area planted annually on rootstocks which was either encouraged by or developed through AGWA-funded R&D projects. This would be constant until 2040, the end of the study horizon.

The majority of estimated rootstock planting area, around 69%, is replacing existing rootstock plantings with rootstock, approximately 1245 ha. The balance would be replacing own-rooted vines with rootstocks, comprising around 549ha.

Future industry growth and/or an increase in rootstock planting rates (% of new planting on rootstock) are considered below under heading 'sensitivity analysis'.

Reconciliation with other data

The other way to understand the volume of rootstock plantings is to use annual sales of rootstock by nurseries and others.

Whiting (year) reported annual sales of rootstock cuttings in 1989-93 at 2.3m and in 2007-11 at 2.7m (Table 11). At an average planting density of 2000/ha (planting densities range from 1600/ha to 3600/ha), these sales imply an annual planting area of rootstock of 1350 ha. The planting to improved rootstock (at 80%) would therefore be approximately 1080 ha per annum.

The difference between the two estimates could reflect a range of factors including:

- Age of vine at replacement - 30 years was used in the analysis while if 40 years was used, the annual rootstock planting rate drops to 1360 ha per annum
- Proportion planted to improved rootstocks (the focus of the current analysis) as against improved plus traditional rootstocks
- Planting density - 2000 vines/ha was used in the analysis while at 1600 vines/ha the annual rootstock cutting sales imply 1350 ha were planted per annum to rootstock
- Any privately grown or field grafted rootstock would not be recorded, but likely to be a very small percentage.

For the base case analysis, an annual planting level of 1800 ha has been used. Most of this area is replacing traditional rootstocks with improved rootstocks.

Total area impacted by alternative rootstock use

The nature of the benefits from rootstocks means that for some benefits the gain is 'one off' while for others there is a stream of benefits over the life of the vine.

- Bringing production from newly planted rootstock forward by a year is a one off. Noting that this benefit generally applies only to the area planted to rootstock instead of own-roots – since the gain is from switching to rootstock rather than improved rootstock over traditional rootstock.
- WUE is an annual saving over the life of the vine (although the gains may differ between years) as are pest resistance, tolerance of salinity and drought. Estimating the total value of these benefits requires estimating the total area each year under improved rootstock. That is, the industry level cumulative area as a result of adding 1800ha each year of improved rootstock.

Table 12: Estimated total area planted/replanted to rootstock/improved rootstock: By "region"

	% of total plantings on rootstock (1)	Area wine grapes (2)	Area other grapes	Total area	Area on rootstock: Base	Growth rate in share on rootstock ("conventional - historical - rate of adoption")	Replanted areas planted to rootstock (av annual growth in past share on rootstock)	Replant required to maintain rootstock share (30 year vine life)	Proportion of rootstock replanting on alternative rootstock	Replant of rootstock share on improved rootstock	Total area planted to improved rootstocks	Ratio Replanting on rootstock: New plantings
ABARES regions	%	ha	ha	ha	ha	Annual percentage point increase on base rootstock level	ha/year	ha per year	%	ha/year	ha/year	
	(a)	(b)	(c)	(d) =(b)+(c)	(e)=(d)*(a)	(f) text estimate	(g)=(d)*(f)	(h)=(d)/(a) *life of vines	(i) text estimate	j=(h)*(i)	k=(g)*(j)	l=(j)/(k)
Big Rivers	17%	21,703		21,703	3,690	0.2%	43	123	80%	98	142	69%
Central and North East Victoria	100%	7,529		7,529	7,529	0.5%	38	251	80%	201	238	84%
Murray Darling Swan hill	68%	18,893		18,893	12,866	0.0%	0	429	80%	343	343	100%
Lower Murray	43%	20,732		20,732	8,935	0.0%	5	298	80%	238	243	98%
Barossa	23%	12,982		12,982	3,038	0.8%	101	101	80%	81	182	45%
Fleurieu	10%	13,358		13,358	1,322	0.8%	114	44	80%	35	149	24%
Limestone Coast	3%	15,165		15,165	500	0.5%	72	17	80%	13	85	16%
		110,362		110,362	37,881					0	0	
(Hunter,Phillip Is., Gippsland, Tasmania, WA)	5%	(b) 35,020		35,020	1,751	0.5%	175	58	0%	0	175	0%
Total		145,382								0	0	
Table grapes	100%		8,700	8,700	8,700	0.0%	0	290	75%	218	218	100%
DVF	100%		1500	1,500	1,500	0.0%	0	50	75%	38	38	100%
Total				155,582	48,081		548	1,661		1,265	1,813	70%

(1) Table 8
(2) ABARES, Bearing + non bearing area
(3) Industry estimates

Source: IDA Economics estimates

Modelling the benefits and costs

Measured benefits

The benefits arising from adoption of the demonstrated value to growers of alternative rootstock have been modelled quantitatively as follows:

- Benefits from bringing forward production - an additional year of production for new plantings
- Benefits from improved nematode resistance - annual benefit for new plantings and rootstock replanting
- Benefits of WUE - annual benefit for new plantings and rootstock replanting.

While recognised, the benefits arising from improved phylloxera resistance (or in some grape areas continued production with phylloxera spread); annual yield increases; salt tolerance; drought tolerance; reduced potassium uptake have not been quantified. The estimated benefits are thus conservative.

Further, given the financial data relates to 2011-12, a challenging and higher cost year based on weather damaged grapes, the annual value of future benefits derived from this data is likely conservative. The 2011-12 season has been used for the estimated benefits in 2014 on the basis that net returns have changed little in the industry. For modelling purposes, the estimated benefits are held constant in real (2014) terms. However, this is somewhat of a simplification since it is unlikely that the industry can continue to supply current volumes and quality at these returns.

Also, the value of benefits, the calculated return per tonne/per hectare, underestimates these returns since the value of grapes used for wine company estate production is not included. Only sales of grapes divided by total production has been used to calculate average prices. This underestimation will be significant in some areas/regions. Again, this means that the estimated benefits are conservative.

Adoption

Adoption of the alternative rootstock has been measured as the area of new rootstock plantings (either as replacement for own roots or as a result of industry growth) plus substituting of alternative rootstock when replanting on rootstock.

Growers adopting rootstock in new plantings can be expected to reap the full benefits of adopting rootstock – from bringing production forward and the annual yield and WUE gains. That said, there will be some learning costs as management plays a key role in achieving these gains and managing vines to avoid yield/quality losses resulting from rootstock vigor.

Growers replanting existing rootstock vines are unlikely to see the same level of gains since the gain from the alterative rootstock is the gain at the margin – the additional benefit from alternative rootstock, not rootstock per se. First, they do gain the benefit of bringing production forward. Second, the extent of the annual gain is the gain from alternative rootstock compared to the existing rootstocks (and not own root vines). In this analysis it is estimated that growers replanting gain half the measured benefit of using rootstock.

Costs of adoption

The cost of using rootstock is significant — estimated at $4.80/vine compared to $1.60/vine for own-rooted vines.

For new plantings, using rootstock is an additional cost. However, for rootstock replanting there is no additional cost since rootstock would have been replanted. The net benefits from adopting rootstock have been calculated on this basis.

Quantification and investment performance: Industry level

The estimated industry benefit (before additional costs of rootstock are included) is $269m (Table 13, 2014 Real Present value terms, 2007-2040 timeframe). About 64% of the estimated benefits derive from improved nematode resistance, 22% from bringing production forward and 14% from improved WUE.

Table 13: Source of benefit

Source of benefit	$m	%
Nematode resistance	$171	64%
Bringing production forward	$58	22%
WUE	$38	14%
Potassium tolerance	$1	0%
Phylloxera Yarra Valley	$1	0%
Total	$269	100%

Source: IDA Economics estimates

The net measured benefits from the AGWA projects (after allowing for additional adoption costs of rootstock on new areas of rootstock) across the industry are estimated at $201m (Table 14) (2014 Real Present value terms, 2007-2040).

Given the AGWA plus co-investor investment of $19m (2014 real, present value), the investment is estimated to have returned the industry $124m or $11 for each $1 R&D invested — an estimated internal rate of return of 35%.

Table 14: Investment performance

Present value benefits	$m	$269
Present value adoption costs	$m	($68)
Present value net benefits	$m	$201
Present value R&D costs	$m	($19)
NPV from R&D investment	$m	$182
Benefit cost ratio		11
IRR		35%

Source: IDA Economics estimates

Sensitivity analysis

Losses from nematodes

The base case uses an estimate of an average yield gain of 10% due to improved nematode resistance from using alternative rootstock. This is noted as conservative since gains of around 25% have been shown in R&D trials in some situations. Sensitivity analysis has been undertaken for yield gains of 5% and 20%.

Water Use Efficiency

In the base case, a reduction in water use of 20% has been used as the gain from using alternative rootstocks. This estimated gain has been applied across all winegrape growing regions. It is more likely that the gains will differ between regions, and these gains might be higher or lower per hectare and with differing implications for yield. The sensitivity of the analysis using a lower and higher gain in WUE has been examined.

Summary

Adopting less conservative, but quite plausible, estimates of the yield gains from improved nematode resistance and WUE gains from using alternative rootstock has a marked effect on the estimates rate of return from the AGWA and co-investor investment (Table 15). Against the base case Benefit-cost return of 10.8, the higher gains suggest a return of around $20 per $1 invested. The internal rate of return is estimated to increase from 35% to around 45%.

Table 15: Sensitivity analysis

Benefit cost ratio

	Yield gain from reduced nematode loss		
WUE	5%	10%	20%
15%	5.7	10.3	19.5
20%	6.2	10.8	20
25%	6.7	11.3	20.5

Internal Rate of Return

	Yield gain from reduced nematode loss		
WUE	5%	10%	20%
15%	27%	35%	45%
20%	28%	35%	45%
25%	29%	36%	45%

Source: IDA estimates

Quantification and investment performance: ’regional’ level

The estimated benefits and adoption costs, on an area/region basis, are presented in Table 16.

Table 16: Estimated benefits and adoption costs: ‘Regional’ level

Region	PV total benefits	PV benefits new plantings	PV benefits replanting on rootstock	PV adoption costs	Net benefit
	$m	$m	$m	$m	$m
Big Rivers	$16.3	$2.4	$13.9	$5.4	$10.9
Central and North East Victoria	$3.8	$2.9	$1.0	$4.7	($0.9)
Murray Darling Swan hill	$45.6	$0.0	$45.6	$0.0	$45.6
Lower Murray	$33.5	$0.6	$32.9	$0.6	$32.8
Barossa	$50.6	$13.8	$36.8	$12.6	$38.0
Fleurieu	$43.2	$13.1	$30.1	$14.2	$29.0
Limestone Coast	$22.2	$8.0	$14.1	$9.0	$13.2
Yarra Valley	$2.3	$0.0	$2.3	$0.0	$2.3
(Hunter,Phillip Is., Gippsland, Tasmania, WA)	$21.5	$16.9	$4.7	$21.9	($0.3)
Table grapes	$26.3	$0.0	$26.3	$0.0	$26.3
DVF	$4.0	$0.0	$4.0	$0.0	$4.0
Total	**$269**	**$58**	**$211**	**$68**	**$201**

Source: IDA estimates

Appendix : Major (by total $ investment- AGWA plus co-investment) completed AGWA rootstock project investments since 2000: short summaries

Identification of virus free clones of the winegrape varieties and rootstocks required in Australia to enable the establishment of elite nuclear source collections for vine improvement schemes

Project number

SAR 00/6

Title

Identification of virus free clones of the winegrape varieties and rootstocks required in Australia to enable the establishment of elite nuclear source collections for vine improvement schemes

Project Supervisor

Nicholas, Phil

Research institution

South Australian Research and Development Institute

Date completed

2003-06-30

Website link http://www.gwrdc.com.au/completed_projects/identification-of-virus-free-clones-of-the-winegrape-varieties-and-rootstocks-required-in-australia-to-enable-the-establishment-of-elite-nuclear-source-collections-for-vine-improvement-schemes/

Key points

Leafroll viruses are the most detrimental of these viruses. They cause yield losses which vary from minor to more than 50% and affect grape quality by delaying maturity and reducing fruit colour in red varieties. Rugose wood viruses can affect vine vigour and yield and cause incompatibility and death of grafted vines.

There are a number of genetic resource collections of grapevines in Australia – the largest of these are held by CSIRO and SARDI. However, when this project began, there were no nuclear collections. These are collections of clones certified free of important viruses, which are established as source material for vine improvement schemes

---

Improving water use efficiency, canopy structure and grape quality by better matching rootstock and scion physiology to irrigation practice

Project number

CRV 99/8

Title

Improving water use efficiency, canopy structure and grape quality by better matching rootstock and scion physiology to irrigation practice

Project Supervisor

Loveys, Brian and Soar, Chris

Research institution

CSIRO Plant Industry

Date completed

2004-03-01

Web site link http://www.gwrdc.com.au/completed_projects/improving-water-use-efficiency-canopy-structure-and-grape-quality-by-better-matching-rootstock-and-scion-physiology-to-irrigation-practice/

Key points

The aims of this project were to provide scientific evidence for the potential of rootstocks to alter vine water use and to establish a better understanding of the physiological mechanisms driving this potential. Research on partial rootzone drying (PRD) had previously demonstrated the importance of root derived chemical signals, in controlling water use efficiency (WUE).

Sustainable salt exclusion by 'salt tolerant' rootstocks

Project number

CRV 02/04

Title

Sustainable salt exclusion by 'salt tolerant' rootstocks

Project Supervisor

Walker, Rob

Research institution

CRCV

Date completed

2006-06-30

Website link http://www.gwrdc.com.au/completed_projects/sustainable-salt-exclusion-by-salt-tolerant-rootstocks/

Key points

Identified the anatomical, morphological or membrane characteristics of roots of 140 Ruggeri that may lead to superior ability for chloride exclusion.

A systematic and smarter approach to breeding and developing grapevine rootstocks adapted to Australian conditions

Project number

CSP 99/2

Title

A systematic and smarter approach to breeding and developing grapevine rootstocks adapted to Australian conditions

Project Supervisor

Clingeleffer, Peter

Research institution

CSIRO Plant Industry

Date completed

2005-12-31

Website link http://www.gwrdc.com.au/completed_projects/a-systematic-and-smarter-approach-to-breeding-and-developing-grapevine-rootstocks-adapted-to-australian-conditions/

Key points

Problems associated with adoption of high vigour rootstocks by the wine industry include negative impacts on berry composition associated with high potassium uptake, high grape juice pH, poor organic acid composition and reduced colour of wine. This project aimed to develop new rootstocks for winegrape production to minimise these problems. A further aim was to develop a smarter, focussed approach to the breeding and selection of rootstocks based on knowledge of the inheritance of key characteristics. Key outputs from the project included phenotyping of ungrafted populations of rootstock hybrids for rooting ability, grafting ability, nematode tolerance, mineral element (particularly K+) discrimination, transpiration efficiency, drought tolerance and root architecture; identification of 20 rootstock genotypes for further evaluation as grafted vines; identification of 4 new, low-medium vigour rootstock genotypes for commercial release with PBR protection; and preliminary analyses of genotype x environment interactions using existing data sets.

Four low to moderate vigour rootstocks were released through licensed nurseries for larger scale commercial evaluation with PBR protection.

Grape composition and wine quality from salt excluding rootstocks and characterisation of the chloride exclusion mechanism

Project number

CSP 06/05

Title

Grape composition and wine quality from salt excluding rootstocks and characterisation of the chloride exclusion mechanism

Project Supervisor

Walker, Rob

Research institution

CSIRO Plant Industry

Date completed

2010-09-30

Website link http://www.gwrdc.com.au/completed_projects/grape-composition-and-wine-quality-from-salt-excluding-rootstocks-and-characterisation-of-the-chloride-exclusion-mechanism/

Key points

This broader range of information will assist grape growers in regions affected by salinity to make informed decisions on rootstock choice

---

Rootstock breeding program and development for Australian wine grapes

Project number

CSP 05/03

Title

Rootstock breeding program and development for Australian wine grapes

Project Supervisor

Clingeleffer, Peter

Research institution

CSIRO Plant Industry

Date completed

2011-09-30

Website link http://www.gwrdc.com.au/completed_projects/rootstock-breeding-program/

Key points

The main purpose of the rootstock breeding program was to maintain the development of new rootstocks with characteristics suited to the Australian environment and industry needs. It aimed to screen new rootstock hybrid families against key selection criteria and investigate the inheritance of key traits to underpin development of future breeding strategies and identify new selections for further assessment as grafted plants.

Salt tolerant rootstocks for long-term sustainability in the Limestone Coast

Project number

SAR 0903

Title

Salt tolerant rootstocks for long-term sustainability in the Limestone Coast

Project Supervisor

Stevens, Rob

Research institution

South Australian Research and Development Institute

Date completed

2011-09-30

Website link http://www.gwrdc.com.au/completed_projects/salt-tolerant-rootstocks-for-long-term-sustainability-in-the-limestone-coast/

Key points

The project addresses these issues by assessing whether the stability of a fundamental property of grafted vines, yield, is affected by aging; by increasing the range of rootstocks for which we have information on salt exclusion properties; by determining whether rootstock salt exclusion properties are modified by reduction in irrigation allocations; and by assessing rootstocks tolerance to conditions of near zero irrigation.

The three Rs – Rootstock, Resistance and Resilience to grape phylloxera

Project number

DPI 08/01

Title

The three Rs - Rootstock, Resistance and Resilience to grape phylloxera

Project Supervisor

Powell, Kevin

Research institution

DPI - Rutherglen

Date completed

2012-05-07

Website link http://www.gwrdc.com.au/completed_projects/the-three-rs-rootstock-resistance-and-resilience-to-grape-phylloxera/

Key points

The research activities conducted allowed the development of improved management practices particularly through an in-depth understanding of the interactions between phylloxera clonal lineages and rootstocks, leading to improved rootstock recommendations for Australian conditions

---

Rootstocks to meet future challenges of the Australian wine industry

Project number

CSP 1101

Title

Rootstocks to meet future challenges of the Australian wine industry

Project Supervisor

Clingeleffer, Mr Peter

Research institution

CSIRO Plant Industry

Date completed

2013-06-30

Website link http://www.gwrdc.com.au/completed_projects/rootstocks-to-meet-future-challenges-of-the-australian-wine-industry/

Key points

GWRDC and CSIRO through co-investment in previous projects have committed to delivering improved rootstocks to secure the development of an economically sustainable, resilient Australian wine grape industry. Anticipated ongoing redevelopment of vineyards previously planted on own roots provides a significant opportunity for adoption.

Achieving water use efficiency and improved drought tolerance with rootstocks

Project number

CSP 0901

Title

Achieving water use efficiency and improved drought tolerance with rootstocks

Project Supervisor

Edwards, Dr Everard

Research institution

CSIRO Plant Industry

Date completed

2013-08-09

Website link http://www.gwrdc.com.au/completed_projects/achieving-water-use-efficiency-and-improved-drought-tolerance-with-rootstocks/

Key points

By utilising more water use efficient rootstocks the industry has an opportunity to improve water use efficiency in the vineyard as part of the normal turnover of plantings. Indeed, through their effect on vine vigour rootstocks have the potential to have a large effect on vine water use, but there is a difference between water use and water use efficiency. This project has attempted to explore the relationship between rootstock conferred vigour, yield and water use, together with their role in drought and salt tolerance.

Rootstocks impart a significant range of drought tolerance, salt tolerance and vigour. The physiology underlying these relationships is starting to be understood and such understanding is expected to be further advanced in future projects. In summary:

- Yield has a positive relationship with canopy area, but the yield gain becomes smaller as canopy size gets larger.

- Yield/canopy area is higher in low to moderate vigour rootstocks than higher vigour rootstocks.
- Crop water use index (an indicator of water use efficiency) is higher in low to moderate vigour rootstocks.
- Scion response to ABA is not strongly modulated by differences in rootstock ABA production.
- Rootstock conferred vigour is highly and positively correlated with root length specific hydraulic conductivity in a glasshouse environment.
- Aquaporin encoding genes are more highly expressed in rootstocks that limit vigour, suggesting a physical mechanism for vigour control.
- There is potential for a rootstock to be both drought and salt tolerant.