Phylloxera and Grape Industry Board of South Australia

Australian Government
Grape and Wine Research and Development Corporation

Grapevine Rootstock Evaluation and Breeding in Germany, France and California.



FINAL REPORT to

GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

Project Number: **PGI 05/01**

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Research Organisation: **Phylloxera and Grape Industry Board of South Australia**

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Final Report to Grape and Wine Research Development Corporation
On
Grapevine Rootstock Evaluation and Breeding in Germany, France and California.

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Cover Picture:

Sunridge Nurseries (Bakersfield, California)

Abstract

Travel to Europe and California was undertaken to meet with key researchers, viticulturists and nurserymen to observe, discuss and compare the analytical methods and approaches to rootstock research, evaluation and breeding.

Valuable information was gathered and contact with key researchers made. Along with gathering information on the rootstock programs in each of the countries visited, an insight into other grapevine research projects was gained. The discussions held and information gathered from this trip will help in the development of a rootstock research project currently being developed by the Phylloxera and Grape Industry Board of S.A (PGIBSA).

Executive Summary

The aim of this GWRDC funded travel was to investigate and gather information on the current rootstock programs being undertaken in Germany, France and California. The principal investigator is currently developing a proposal for further rootstock research in Australia on behalf of the Phylloxera and Grape Industry Board of South Australia. The study tour provided an ideal opportunity to discuss the philosophies of evaluation and breeding with leading researchers in this field. Valuable contacts were made with key researchers and industry personnel in all three countries and a large amount of information relevant to the Australian wine industry was gathered.

Rootstock Breeding

The main emphasis of the rootstock programs in each of the countries visited is on breeding for local pests and conditions. The aim of the rootstock program at Geisenheim in Germany is to breed rootstocks with complete phylloxera resistance and is based on the hypersensitive response elicited by *v. cinerea* (Arnold). The INRA program in France is using *muscadinia rotundafolia* to breed for resistance to the vector of Grapevine Fanleaf virus (GFLV), *xiphinema index*. The UC Davis program in California is also using *m. rotundafolia* to breed for resistance to the vector of GFLV, *x. index* and also has a program breeding for resistance to virulent populations of root-knot nematode (RKN). In each program the secondary breeding objectives are for adaptation to local conditions and it is this objective that has the greatest implications for Australia. While the Australian industry could import rootstocks from these overseas programs it must be noted that they have not been bred for our conditions. A good example of this is the RKN breeding program in California which is based on crosses of the rootstocks Schwarzmann and Ramsey. Both of these rootstocks have high potassium uptake. In California this is not a problem because of the low potassium soils, but in Australia this has serious implications because our soils are generally high in potassium and the use of these rootstocks often leads to high juice pH and poor colour. The CSIRO has recently released four rootstocks bred for Australian conditions. The evaluation of these rootstocks should be a high priority. Further breeding for rootstocks with low vigour, broader nematode resistance, greater drought tolerance or even resistance to *x. index* may be a better long-term option than relying on rootstocks from overseas programs.

Rootstock Trials and Evaluation

The approach to rootstock trials and evaluation in Australia and the rest of the world has been to use replicated trial designs. While these trials produce good general information on rootstock performance, the information is limited in its commercial applicability. There have been a number of clonal trials established in California where replicated trials have been established next to whole row trials. In this approach both designs complement each another because scientific evaluation with tests of significance on relative vine vigour and yield components can be undertaken on the replicated trials while commercially applicable data on the management of different rootstocks can be gathered from the whole row trials. This approach should be seriously considered for Australian rootstock trials in the future.

National Co-ordination

In all three countries visited, vine improvement is the responsibility of one umbrella organisation. In Germany the distribution and evaluation of material is controlled by the government through the research stations. In France, ENTAV controls the evaluation and distribution of material, and in the U.S, Foundation Plant Services controls the distribution and to a lesser extent the evaluation of material. The current weakness in the Australian system it seems is that individual groups are conducting their own clonal or rootstock trials on the clones or rootstocks that they have selected or imported. The reported results may or may not be biased but there is obviously commercial advantage in reporting positive results for a particular clone or rootstock that an organisation holds the rights too. It seems that a facility along the lines of ENTAV would be extremely beneficial to the Australian industry, whereby the initial clonal or rootstock data is provided by a neutral source using uniform protocols and would ensure that growers are getting reliable information on the performance of a clone or rootstock.

At this point in time Australia does not have a national approach to rootstock research or a national rootstock program. The national rootstock research forum currently being organised by the PGIBSA for November will be the first step towards greater co-ordination between groups and will hopefully lead to a national approach to rootstock research.

Conclusion

It is important to understand that the Europeans and North Americans are investing heavily in rootstock research and breeding, not because they necessarily want to, but because they don't have a choice. Rootstocks are their primary tool to ensure economic and environmentally sustainable grape production. Given the potential of rootstocks to increase production efficiency and alleviate the problems associated with declining water quality and availability is the situation any different in Australia. Will rootstocks be our primary tool for ensuring economic and environmentally sustainable grape production? It is not an unreasonable proposition that the long-term viability (50-100 years) of the Australian wine industry depends on rootstocks, we may be using them for different reasons to the Europeans and North Americans but the end result will be the same.

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1. Project Aims and Performance Targets

- Meet key researchers and viticulturists and observe, discuss and compare the analytical methods and approaches to rootstock research, evaluation and breeding.
- Establish and consolidate contacts to help facilitate information exchange.
- Explore soil/rootstock relationships and the effects of cultural practices on rootstock performance under U.S. and European conditions.
- Gather information and report on the use of low-vigour rootstocks that may be suitable to Australian conditions.
- Communicate the outcomes of these experiences to colleagues in rootstock research, viticulture and the industry in general.

Establish and consolidate contacts to help facilitate information exchange	1) Meet with Dr Ernst Rühl and his colleagues at Geisenhiem. 2) Meet with researchers at INRA 3) Meet with Dr Andrew Walker and his colleagues at UC Davis 4) Meet with Dr Nick Dookozlian (E and J Gallo) 5) Meet with Dr Micheal McKenry (Kearny Ag. Centre)	18-19th July 20th-22nd July 1-2nd August 3rd August 4th August
Observe and report on the analytical methods and approaches to rootstock research, evaluation and breeding. Gather information and report on the use of low-vigour rootstocks that may be suitable to Australian conditions.	Visit rootstock trial sites in • Geisenheim • Montpellier • Bordeaux • Monterey	August-September 2005
Communicate the outcomes of the experiences to the industry	GWRDC Travel Report Presentation to PGIBSA Annual Grower Meetings Submit Article to Australian Grape and Wine Industry Journal	September 05 August-September 05 November 05 November 05

2. Travel Itinerary

July	Saturday	16	Depart Adelaide
	Sunday	17	Arrive Frankfurt, Germany. Travel to Wiesbaden
	Monday	18	Geisenheim
	Tuesday	19	Geisenhiem
	Wednesday	20	Travel Wiesbaden- to Bordeaux
	Thursday	21	INRA Bordeaux
	Friday	22	Visit of Bordeaux vineyards Travel Bordeaux to Montpellier
	Saturday	23	INRA Montpellier
	Sunday	24	Montpellier
	Monday	25	Languedoc-Roussillon region
	Tuesday	26	Visit ENTAV Travel Montpellier to Paris
	Wednesday	27	Paris-San Francisco
		28th-30th	San Francisco
	Sunday	31	Travel San Francisco to Davis
August	Monday	1	UC Davis
	Tuesday	2	UC Davis Foundation Plant Services Travel Davis to Modesto
	Wednesday	3	E and J Gallo Winery at Modesto
	Thursday	4	Travel Modesto to Kearny Kearny Ag. Centre Travel Kearny to Monterey
	Friday	5	Monterey County Travel Monterey-San Francisco
	Saturday	6	Depart San Francisco Arrive LA
	Sunday	7	Travel LA to Bakersfield
	Monday	8	Visit Sunridge Nurseries in Bakersfield
	Tuesday	9	Travel Bakersfield to LA
	Wednesday Friday	10 12	Depart LA Arrive Adelaide

3. Summary of Travel

18/7/05 Geisenheim Institute for Grape Breeding and Grafting

The first morning of the tour was spent with Dr Joe Schmid a researcher at Geisenheim whose main activities include; cross breeding of rootstock cultivars and management of phylloxera infested vineyards. Dr Schmid conducted a step-by step tour of the breeding program being undertaken at Geisenheim. The aim of the program is to breed rootstocks with complete phylloxera resistance and is based on the hypersensitive response elicited by *v. cinerea* (Arnold). The program has already successfully bred and released one rootstock with complete resistance (Börner) and now aims to develop rootstocks with greater lime tolerance and better nursery characteristics compared with Börner. The breeding program has 6 important stages:

1) **Cross Breeding** with v. cinerea leads to anywhere between 5,000-16,000 individual varieties.
2) **Test for hypersensitive reaction in glass house**. Each of the individuals are inoculated with phylloxera leaf galls and then evaluated for their leaf resistance measured by the production of a hypersensitive response. Approximately 100-120 out of the 5,000-16,000 individuals have leaf resistance.
3) **Rooting and wood production and ripening in the glass house**. The breeders understand that nurseries will only produce a rootstock if it has good nursery characteristics, so ensuring that the individuals have good rooting ability, wood production and wood ripening is a high priority. Any individuals that don't have these positive characteristics are screened out early in the process.
4) **Field evaluation for rooting ability, wood production and ripening.** Evaluation takes place in the field and normally results in a 10% selection rate (10 from 96 in 2004).
5) **Field evaluation under commercial nursery conditions**. Wood production is measured and only individuals that produce economic levels of planting material are retained. The wood produced is then used for the next evaluation stage.
6) **Graftability.** The grafting success is measured for each selection.
7) **Field Evaluation with scion.** The data collected includes:
    - vigour (1-10 scale)
    - Observed leaf colour, chlorophyll meter.
    - Shoot number
    - Bunches/shoot
    - Berry weight
    - Skin:pulp
    - Colour (anthocyanins)
    - Composition including K and N



Inoculation with leaf galls



Field Evaluation

The afternoon was spent with Dr Ernst Rühl (Institute Director) discussing his philosophies on breeding, tracing and record keeping of plant material. At Geisenheim they use a system whereby single vine selections based on positive observed characteristics are chosen, multiplied and planted out in full rows of approximately 100 vines. Once established further selection within the full rows (approximately 3 of the 100 vines) is undertaken and these are then planted out in full rows. This continues and eventually the original selections are removed. Because the philosophy in Germany is not to use HWT treatment this system ensures that virus does not build up in the planting material collection.

We also had a long discussion on the general state of the German industry with particular reference to rootstock use and how growers decide which rootstocks are best suited to their site. Planting decisions are mostly driven by nurseries with some extension officer involvement, but are also often determined by the 'whim' of the winemaker, rumour and gossip (similar to Australia). Currently low vigour rootstocks from France are 'in' and he warned to be careful following the trends of other regions and countries. The most commonly used rootstock in Germany is SO4 because of its wide adaptability.

19/7/05 Gesienheim Institute for Grape Breeding and Grafting

The morning was spent with Dr Schmid in the Rhinegau region visiting one recently established trial and one established trial (see below).

Riesling Trial Hattenheim

- 17 years old
- Good soil, well drained, fertile good water holding capacity
- 10 years data collection (age 7 onwards)
- No significant difference in performance based on 10 year average (some differences between hot and cold years), which is a typical response to Riesling on good soils and generally only see differences in more difficult soils.

We also visited a couple of wineries during the course of the morning, of particular interest was one winery which is using glass 'corks'. They eliminate the risk of taint but still provide the consumer with the experiential 'pop' when the wine is opened. The 'cork' looks sophisticated and is relatively cheap at 35 euro cents/unit. A possibility for Australian wineries?

In the afternoon Dr Rühl took me on a tour of their experimental vineyards and grafting facilities. Across the institute they have 12 Ha of planted vines with approximately 1000 different accessions. The institute also has a commercial operation with 30,000-40,000 cuttings processed each year. The day was finished off with a tour of the steep slope vineyards along the Rhine.

21/7/05 INRA Bordeaux

The first part of the day was spent at INRA with Dr Nathalie Ollat, Dr Stephane Decrooq and Dr Andrew Walker (who was visiting from the U.S.) Nathalie gave a presentation on current rootstock use in France and also on the breeding program at Bordeaux. Currently three rootstocks dominate; SO4, 110 Richter and 3309C. Rootstock use on individual varieties is as follows:

- Merlot: S04, 110 Richter, 3309C
- Pinot Noir: 41B (poor phylloxera resistance) and SO4
- Shiraz: 140 Ruggeri, 1103 Paulsen and SO4.

As with Germany, SO4 is widely used because of its ability to adapt to a wide range of soils. The comment was made that while SO4 may not be the best rootstock in every situation, growers consider it a 'safe' choice.

The breeding program at Bordeaux remained stagnant during the 1990's but was revived in 1999 because of the high incidence of Grapevine Fanleaf virus (GFLV) in Bordeaux vineyards. A survey revealed that at least 30% of vineyards have GFLV. GFLV is spread by a species of dagger nematode*, xiphinema index.* The main effect of the virus is on yield and causes vineyards to become uneconomical after 15-25 years. The program is based on *Muscadinia rotundafolia*, an American vitis species which has immunity to nematode attack. Other breeding objectives include phylloxera resistance, tolerance to lime (high pH) soils, low conferred vigour and high fertility (flowering and fruitset). As with the Geisenheim breeding program, the program in Bordeaux has a number of stages. An important factor in the success of a breeding program is establishing a method for early identification of individuals with positive characteristics. This can be done through genetic identification, in vitro testing for *x. index* or phylloxera resistance or observation of growth for vigour or lime susceptibility.



Iron chlorosis evaluation

Other methods of identification are to try and establish links between characteristics. Some recent experiments at INRA Bordeaux have shown that there is an inverse relationship between lime tolerance and vigour, in that as vigour increases, lime tolerance decreases. This obviously makes the process of breeding difficult when the breeding objective is for high lime tolerance and low conferred vigour.

Following Dr Ollat's presentation I gave a brief presentation on the history of the Phylloxera and Grape Industry Board of S.A. its current early detection program and what the board was planning to do with the rootstock project. This led to a very interesting discussion on the state of the Australian industry with regard to rootstock use and phylloxera. Both Dr Wallker and Dr Ollat expressed their concern and disbelief that the Australian industry, which prides itself on being at the forefront of research on viticulture and winemaking, could leave itself so unprotected to something that is so easily overcome.

Following this we were shown around the research station to have a look at where the testing for phylloxera resistance, *x. index* resistance and tolerance to high pH conditions takes place. Some novel methods were observed including the use of gravel as a medium for phylloxera resistance evaluation. The gravel medium, is used because it is easier to dig out the roots for phylloxera nodosity evaluation.



After this we had a look through the station's germplasm block. The germplasm block contains many different vitis species, mostly from North America but also some from Asia. Nathalie commented that the vitis species in the germplasm block are essentially the 'tools' for breeders and that they aim to have as many ascensions as possible in the collection. While 90% of the collection is considered 'junk' it is important to have a large and diverse collection just in case a problem that could be mitigated by a particular species arises.

Gravel medium used for phylloxera resistance testing



INRA experimental research station 'Domaine Du Grand Parc',

In the afternoon we toured the INRA experimental vineyard at 'Domaine Du Grand Parc'. The vineyard has 30 planted hectares with a majority of the plantings devoted to rootstock research. Some observations include; some rootstocks decrease vigour and yield, while some tend to only reduce vigour. An example is Riparia Gloire, which reduces vigour but not yield to the extent that it may not have the leaf area to ripen the crop load, whereas101-14 tends to decrease yield more than vigour. Therefore when collecting data and analysing results it is important to separate vigour from fertility (yield). In a trial where nutrient and water inputs were altered they found that there was a positive correlation between the level of nutrient and water inputs and biomass production for each of the rootstocks. In a commercial perspective this means that management has a large effect on rootstock performance which supports what

we have seen in the first year of the rootstock project in South Australia. In these trials they also found that the relative rankings of the rootstocks did not alter but shifted up and down the scale depending on the inputs.

Dr Ollat commented that her superiors believe that they have learnt as much as they can from the evaluation of the commonly used rootstock so most of new trials are related to the evaluation of newly bred stocks. Data collection for these trials is from every individual and begins in the first season and includes: phenology, vigour (pruning weight and shoot length), yield, ripening and composition.

22/7/05 St Emillion, Bordeaux

In the morning we travelled out to Chateau Ausone in St Emillion and met up with Marteen van Helden and Kees van Leeuwen (Professors at the viticulture school in Bordeaux). The main varieties grown in St Emillion are Merlot, Cabernet Franc and to a lesser extent Cabernet Sauvignon. In the older plantings the main rootstocks used include 41B and SO4. SO4 was widely planted in Bordeaux partly because of its wide adaptability but mainly because it is easy to graft and following the 1956 frosts, which killed vast areas of vines, this was an important consideration. 41B was widey planted because of its excellent lime tolerance but it is now being replaced with Fercal because of its relatively poor phylloxera resistance (it has Vinifera in its parentage). More recent plantings have been with 101-14, Fercal and 3309C.

The Chateau Ausone vineyards are having problems with *x. index* and GFLV and have asked the INRA scientists and the professors to help them control the nematode. The main symptoms of GFLV are reduced set along with leaf symptoms such as leaf mosaic, distortion and asymmetrical leaf formation. Leaf symptoms are more obvious early in the summer when temperatures are cooler.



Martin van Helden in front of a vine expressing strong GFLV symptoms



GFLV effects on set and vigour



GFLV infected vines which are infested with Blister mite form white blisters.

Currently the standard practice for *x. index* control is to let the ground fallow for two-three years, but research has shown that populations can survive for up to 9 years. They have tried using fumigation but because the nematode populations reside deep in the soil below the compaction layer they can not get good efficacy. After Chateau Ausone we visited other GFLV affected vineyards at Cheval Blanc. Here they have set-up a trial testing the effects of different deep rooted crops for their nematicidal effects. There are no results as yet.

23/7/05 INRA Montpellier

Montpellier is situated in the region Languedoc-Roussillon. Languedoc-Roussillon is considered the 'bulk' production area of France. In 2001 there were 297,000 Ha of vines planted in this region. The planted area has decreased by 17% since 1988. The main varieties planted are Carignan, Grenache and Cinsaut, however in the last 15 years the area of Cinsault and Carignan have decreased and have been replaced by Shiraz, Merlot, Cabernet Sauvignon, Chardonnay and Sauvignon blanc.

	1988	**2000**
Carignan	**167.1**	**93.5**
Cinsault	**48.2**	**30.5**
Grenache	**86.7**	**97.1**
Shiraz	**14.5**	**30.5**
Merlot	**9.1**	**25.3**
Cab. Sauv.	**4.7**	**13.1**
Chardonnay	**1.1**	**8.9**
Sauv. Blanc	**0.5**	**4.5**

Table showing 100,000's of hectares of varieties planted in Languedoc Rousillon

The main rootstocks used include; 110 Richter (39%), 140 Ruggeri (18%), SO4 (17%) and 3309C (7.2%) and 1103 Paulsen (4.8%). It is interesting to note the differences in rootstock parentage between Bordeaux and Languedoc-Roussillon. In Bordeaux the rootstocks are dominated by *v. riparia* parentage (earlier ripening, low vigour, poor drought tolerance) whereas in Languedoc-Roussillon the main parent is *v. berlandieri* (drought tolerant, salt tolerant, higher vigour, and well adapted to infertile soils).

The morning was spent with Dr Alain Bouquet discussing the Montpellier breeding program. The program began in the 1950's and early breeding was for a rootstock with high lime resistance and higher phylloxera resistance than 41B (the rootstock used widely at the time for high lime soils), the result was Fercal. The next objective for the INRA breeding

programme was for a rootstock with high tolerance to acid soils, the result being Gravesac. A breeding program for *x. index* resistance was established in 1981 and is based on *m. rotundafolia*. The breeding program is necessary because *m. rotundifolia* is graft incompatible (will not form a graft union) with *vitis vinifera* and also has very poor lime tolerance (European soils are generally high in lime).

The results of the original crosses using *m. rotundifolia*, were sterile or very poorly fertile, so could not be easily used for further crossing. Even crossing with more fertile species (in this case 333EM) yielded only four genotypes from the original 700 F1 progeny. These four genotypes have been planted in field trials for evaluation for comparison with known rootstocks such as Börner, SO4 and 140 Ruggeri. It is interesting to note that Börner has been shown under these conditions not to be resistance to attack by *x. index* despite the Geisenheim claim of complete resistance to soil pest attack. The field trial results are positive with only one of the new crosses succumbing to *x. index* attack. The program is continuing with more F1 progeny growing in the glass house in preparation for field evaluation.



Marselan on x. index resistant rootstock. Note excellent berry set which would not occur on susceptible rootstock.

This part of the tour again highlighted the importance that the French (and Germans) place on rootstock breeding for local pests and conditions and also that there are no 'quick fixes' in classical breeding. If an issue arises in Australia do we have the facilities, plant material sources or expertise in place to begin a program for ourselves?

25/7/05 Montpellier Day 2

The day was spent with Dr Alain Bouquet and Dr Laurent Terragrosa (Laurent works for INRA and lectures at the university) along with members of the local agricultural bureaux. The first site we visited was a vineyard planted with Chardonnay on its own roots. This vineyard is situated in a unique part of the region where flooding is used to 'control' phylloxera. As a result it is also one of the few places in France where it is possible to observe root tuberosities. The conditions which make this management possible include being situated on a very flat site with a reliable water source. The reason for this form of phylloxera management is economics in that the growers do not have to pay for grafted material. This method requires that the vineyard be submerged under 20 cm (2ML) of water for between 40-50 days each winter. There is a fine balance in the length of the submersion; not so long that the anaerobic conditions lead to poor early growth, but long enough to reduce the population levels below economic thresholds. Anywhere between 3-5ML of water is required to sustain the water level at 20cm, depending on the permeability of the soil. As can be seen in the photos the control method does not give anywhere near 100% efficacy with

tuberosity formation and leaf galling evident. There are only 2000 Ha being managed this way in France and considering the level of control or lack thereof, this is not surprising.



Rust marks indicating water height



Tuberosities on own roots

Considering the water issues in Australia this method of control would not be suitable. What this experience really highlights is that despite the best attempts by these growers to control phylloxera using cultural methods other than rootstocks, they are barley able to remain economically viable.

The rest of the day was spent visiting vineyards around the region and investigating the causes associated with unexplained dieback, which is a typical exercise undertaken by the employees of the Agricultural bureaux's. The bureaux it seems, takes very seriously any dieback issue associated with grapevines, regardless of the scale. This is most probably a hangover from the initial phylloxera infestations.

26/7/05 ENTAV



Sandy soils of ENTAV clonal collection

I meet with Jean-Micheal Borsequoit and toured the ENTAV facilities. Each clone must undergo a number of tests done under strict protocols so as to ensure that only the best material is released to growers. The facility is also a repository for over 18000 accessions including virus free and virus infected material. The facility is situated in near proximity to the sea and the site was chosen because of the inability of phylloxera and *x.index* to survive in the beach sand soils (photo left). Root-knot nematode however is able to survive under these conditions and as a result all clonal selections are planted on rootstock. The rootstock used is SO4 because it has excellent RKN resistance.

1/8/05 UC Davis

Dr Andrew Walker took me on a tour of the facilities at UC Davis including the laboratory and germplasm collection. During this time we had an in-depth discussion on a range of rootstock and non-rootstock related issues. The drought tolerance and water-use efficiency of rootstocks was one of the more interesting areas discussed, particularly as Dr Walker's work in this area contradicts some of the work in Australia. In his research he has not observed any differences in transpiration efficiency between rootstocks regardless of whether they have been ungrafted, grafted or reciprocal grafted (M. Padgett-Johnson, L.E. Williams, and M.A. Walker, 2003). This contradicts previous studies in Australia by Smith (2003) and Walker (2004).

Some other interesting points raised were that in Dr Walker's experience the only American vitis species with true drought tolerance is *v. monticula*. Other rootstocks are drought adaptable but not tolerant in that they will not survive without water whereas *v. monitucla* will survive. He is also of the opinion that Shiraz and Grenache on their own roots will also survive long periods without water and are probably more drought tolerant than other rootstocks. Considering the water situation in Australia and the apparent drought tolerance of *v. monitulcula*, this vitis species would be a useful addition to the Australian germplasm collection.

We also discussed the rootstock Börner's lack of full resistance to French and Californian phylloxera populations. According to Andy, phylloxera is very adaptable despite its asexual reproduction and in *in vitro* studies they have adapted leaf feeding populations to root feeding and vice versa in a relatively short period of time (5 generations). This has implications for using Börner for phylloxera eradication in Australia because although studies with Börner on Australian populations of phylloxera have shown that it does not feed on roots, this may change over time. The PGIBSA is currently establishing trials with Börner to see if it will perform under Australian conditions. While it is unlikely that Börner is a long-term option for phylloxera eradication it is the most resistant rootstock available so should at least be evaluated under Australian conditions.

I also spent time in the lab talking with his research assistants about the work they were doing. His lab studies the genetics of resistance to phylloxera and *x. index*, their genetic diversity and aggressivity, and host/pest interactions of these pests with grape species. Dr. Walker's lab is also actively involved in breeding table, raisin and wine grapes for resistance to Pierce's disease and powdery mildew. Lab activities include classical breeding and inheritance studies, the development of rapid resistance assays, field trials of promising rootstock and scion selections, DNA marker analysis and mapping, and genetic engineering.

2/8/05 Foundation Plant Services and UC Davis

The morning was spent at Foundation Plant Services, which is situated a couple of kilometres off-campus. Foundation Plant Services was established in 1958 to maintain and distribute virus-tested cherry and vine planting material. FPS is now responsible for producing, testing, maintaining and distributing disease tested propagation material of Cherries, vines, strawberries, roses, fruit tress, nut trees and sweet potatoes. Deborah Golino (Director) gave me some background on the FPS and Susan Nelson-Kluk (Grape Program Manager) took me on a tour of the facilities

The afternoon was spent with Dr Jeffrey Grannet (UC Davis Department of Entomology) who is working on rootstock/phylloxera interactions and in particular fungi-associated insect linked vine decline. This work has come about because of instances of rootstock decline in Hungary and Germany, with SO4 and 5C Teleki and more recently in California with 101-14 and 5C Teleki.

Dr Grannett believes that the root rotting fungi, fusarium, has a large role in the decline of phylloxera infested vines. To test this they used 'root-socks' to create a controlled environment. They found that fusarium + no phylloxera led to no decline. Therefore rootstock resistance is not only a function of nodosity formation (population levels), but also susceptibility to Fusarium.

Another interesting finding from their work is that they have observed that the phylloxera and fusarium populations have become more virulent over time. The theory is that the longer infested vines are left in the ground the greater the chance of replant rootstock failure. This is what occurred in the plantings of 101-14 and 5C Teleki, in that the vineyard was previously planted to AXR1 and was left to decline over a long period of time post-infestation, allowing for the development of greater virulence in the pest and pathogen. The implications for Australia is that if phylloxera was to spread into susceptible vineyards the infested vines should be removed straight away to reduce the risk of rootstock decline.

His team has also found that there is a great deal more variation in phylloxera populations than previously thought. In one vineyard with three rootstocks they found 6 genetically different phylloxera populations. Considering that they have yet to have success in trying to get phylloxera to mate in vitro i.e. there is no sexual recombination, the question he is trying to answer is; where is the variation coming from? One possibility is that sexual form of phylloxera (allates) may be doing there 'business' underground.

3/8/05 Modesto and Surrounds (E and J Gallo)

The purpose of this visit was to renew contact with Dr Nick Dokoozlian (Vice-president of Viticulture, E and J Gallo Winery) and get an industry perspective on rootstock evaluation as well as to get a general overview on Californian viticulture and the general state of the industry.

The most important thing that came out of the discussions with Dr Dokoozlain was the approach to rootstock trials and evaluation and the usefulness of replicated trials vs. whole row trials. There have been a number of clonal trials established in California where replicated trials have been established next to whole row trials. This way scientific evaluation with tests of significance on relative vine vigour and yield components can be undertaken on the replicated trials while commercially applicable data on the management of different rootstocks can be gathered from the whole row trials. In this approach both designs would complement one another and should be the approach taken for Australian rootstock trials in the future.

During the course of the day the Dr Dokoozlian gave an update on the current situation with Pierce's disease (PD) and Vine Mealybug.

Pierce's Disease

The co-ordination of monitoring, tracking and trapping of the PD vector the glassy-winged sharp shooter has ensured that the disease is currently under control. However, while the vector is controlled there is still high levels of incoculum (*Xlyella fastidiosa)* in vineyard areas (particularly the Napa) so the risk is still there.

Note: Dr Walker (UC Davis) and his team are currently working on PD resistant varieties. There has been some success in that they have managed to breed varieties that prevent vine death, but unfortunately these varieties still harbour the pathogen. This would mean that while these PD resistant varieties would survive they would become long-term inoculum sources for non-PD varieties. In the PD resistant varieties they have observed that pathogen is only allowed to move vertically and not horizontally into the vascular bundles (susceptible

varieties allow movement horizontally into the vascular bundles, which blocks the phloem leading to plant death.) The breeding program is continuing.

The Vine Mealybug (*Planococcus ficus)*
The Vine Mealybug (VMB) has become a serious economic pest in California. The VMB feeds on the vines and secretes large amounts of sugar water. This sugar water often leads to the production of sooty mould which seriously affects the fruit quality. Once established in vineyards VMB is extremely difficult to control with insecticides. The VMB is currently being spread by some nurseries that choose not to hot water treatment their planting material before distribution. The industry is currently investigating a form of biological control.

4/8/05 UC Davis: Kearny Agricultural Centre
Dr. Michael McKenry (UC Davis Nematologist)
The aim of this visit was to meet with Dr Micheal McKenry the leading nematologist in California and find out about the current rootstock/nematode breeding programs and discuss nematode/rootstock interactions. The program began in 1981 after they found that their most nematode resistant rootstocks were beginning to breakdown under high nematode pressure. The main issue is that all rootstocks have only one mechanism of resistance found at the root tip, once the mechanism is broken down the rootstock is open to attack. Importantly though the mechanism of resistance is different between the rootstocks. The aim of the program was to breed rootstock with multiple levels of resistance. McKenry and his colleagues noticed that Schwarzmann and Ramsey have good resistance to various nematode species and that the moderating vigour effects of Schwarzmann may temper the vigour of Ramsey. Following crossing and evaluation they have come up with three rootstocks that look to have good potential. One in particular looks to have three modes of resistance so should be durable. Importantly though in the three years since its release it has performed well in the field. Unfortunately this rootstock has relatively poor phylloxera resistance, although in most cases this has not been a problem because of the inability of phylloxera to establish in coarsely textured, nematode susceptible soils.

The Californian experience with nematodes and this work by McKenry has serious implications for Australia and South Australia in particular because of its wide range of nematode species. There have already been documented cases of the breakdown of Ramsey under high nematode pressure (Walker, 1997). Given that nematode populations will only increase over time and that the use of rootstocks will select for populations with more virulence there will probably be the need for a rootstock in Australia with multiple levels of resistance. While Australia could import the recently released rootstocks their parentage, Schwarzmann and Ramsey, both lead to high potassium uptake, which negatively effects grape juice pH. Soils used for viticulture in Californian have relatively low levels of potassium compared with Australian viticultural soils so the uptake of potassium is not an issue over there, while in Australia it is a serious consideration. There are two options 1) import the rootstocks and evaluate under Australian conditions or 2) begin a breeding program for Australian nematode populations and conditions.

Dr Matthew Fidleibus
While I was at Kearny I took the opportunity to meet Dr Matthew Fidelibus who is the UC Davis viticultural advisor for the region. Dr Fildelibus is currently working on a number of different projects covering wine, table grape and dried fruit production. Two trials of particular interest are with a ‘Dried on Vine; (DOV) system for dried fruit production and trials with ABA for table grape colour.

Dried on Vine (DOV)
The DOV system as seen in the photos relies on the same theory as the Australian 'Shaw Swing Arm' trellis in that the canes are cut and allowed to dry resulting in raisins that can be harvested by mechanical means.



DOV Non-fruiting mid-row



DOV fruiting mid-row

The vines are trained to an overhead horizontal trellis system with alternating fruiting and non-fruiting rows. The fruiting canes are placed in one mid-row and the renewal or non-fruiting shoots are trained to the next mid-row. Unlike the Australian designed Shaw Swing Arm the DOV system does not use drying oils.



Table Grapes and ABA
CPPU, a synthetic cytokinin (hormone), has the potential to be used in the table grape industry to increase berry size. However CPPU negatively effects colour development, so Matthew has been experimenting with applications of ABA to increase colour development. The early results are promising with berries exhibiting a strong response.

ABA application trial: L-R- 150ppm, 300ppm and control (0ppm)

5/8/05 Central Coast with Larry Bettiga (UC Davis Extension Officer)

The Central coast region was established in the 1960's and consists mostly of large company vineyards. The region is quite cool and experiences strong winds. The principal varieties are Chardonnay and Pinot Noir. The western side of the region has fertile soils so the vineyards there are commonly grafted to lower vigour rootstocks such as 101-14, 5C Teleki and SO4. The eastern side of the region has lower vigour soils and experiences stronger winds so higher vigour rootstocks such as 1103 Paulsen and Ramsey are commonly used.

110 Richter Issues with Chardonnay

At one trial site they have observed problems with 110 Richter when grafted to Chardonnay. The vines exhibit RSG-like symptoms (uneven budburst, devigorated shoots etc.) and the problem seems to be related to the short bursts of warm weather in late winter. They have observed similar symptoms on other varieties but the problem is worst on Chardonnay. This has implications for 110 Richter in the Riverland where similar late winter conditions to those experienced on the Central Coast of California are possible. The planting area of 110 Richter in the Riverland is likely to increase over the next few years so it will be interesting to see whether we observe the same problems.



110 Richter displaying RSG-like symptoms (left) adjacent 5C Teleki

Bill Petrovik- St Bernabe

St Bernabe is a 3600 Ha vineyard situated on the relatively infertile, eastern side of the valley. In the past the vineyard was mostly planted to 5C Teleki, 5BB Kober and SO4 with smaller plantings of Ramsey and 1103 Paulsen. While the 5C Teleki, 5BB Kober and SO4 performed adequately, Bill recognised that 1103 Paulsen and Ramsey, with their more extensive root systems, were able to increase production efficiency through using less water and fertiliser and by spending less time applying these inputs. For example by using slow release fertilisers they went from 12 passes/year to 4. On a large vineyard such as St Bernabe this adds up to large savings. This is a great example of how judicious choice of rootstock can lead to greater returns/Ha.

8/8/05 Sunridge Nurseries

Sunridge is a high quality nursery located in Bakersfield with more than 240 hectares of certified rootstock, scionwood increase blocks and outdoor nursery blocks. In full production the nursery can produce 20 million cuttings/year, which equates to 130,000 cuttings/day during the grafting season. The nursery has a very high average grafting success (91.7%) which Steve Maniaci, the nursery production manager, puts down to having extremely high hygiene standards. The other reason for such high success rates is that they have developed a 'recipe' for each scion/rootstock combination. The 'recipe' is a result of extensive trial work; for example altering temperatures before and after grafting. During the visit they were trialling scouring of the rooting part of the stick in an attempt to get better callusing.

4. General Information

Rootstock Long-term Viability

There has been anecdotal evidence circulating around the Australian industry based on information from overseas that the viable life of a rootstock was only 20-30 years because of breakdown of the graft union. In Germany the 25-30 turnaround of plantings has occurred but it has not been a result of the rootstock graft breakdown, instead it has been a result of industry cycles. The last round of replants occurred as growers moved to newer varieties and 25-30 years prior to this the change in planting was a result of the move to mechanisation.

In France the 25-30 year turnaround has been a result of a number of issues; in 1956 a severe frost killed large areas of vines. 25 years later plantings were removed because of Grapevine Fan Leaf Virus (GFLV) and the move to mechanisation. 20-25 years after this, vines were replaced again because of GFLV. In California the replacement of plantings 15 years ago was because of AXR1. Prior to this the story is similar to that of Germany in that mechanisation and change in variety has driven replacement and not breakdown in rootstock graft union.

Abandoned Vineyards

In Australia there is some concern within the industry that abandoned vineyards may become a problem because of the potential for the build-up of pests and disease inoculum. Growers are currently not obliged to remove vineyards. PGIBSA requested that I investigate what different countries where doing to over come these issues. In Germany the government is currently working on legislation. One idea that has been suggested is to lease the property to neighbouring growers at reduced rates. One of the major issues in Germany is that most of the abandoned vineyards are on the steep slopes in the 'tourist regions' and so removal is not an option, instead the government is subsidising production of these vineyards. In France abandoned vineyards are a source of leafhoppers and therefore inoculum for yellows disease (Flavesence doree. The government has legislated that 10000 Ha of uneconomical vineyards are removed with growers being paid $6000 euro/ Ha. In California the vineyards are replaced with higher potential crops such as almonds (or houses!) before they became a problem.

5. Key Recommendations

- The establishment of CSIRO rootstock trials across Australia.
- Stocktake of available accessions in germplasm collections across Australia, including general health and virus assessment.
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- Identify and import key accessions based on stocktake for addition to germplasm collection.
- Where rootstock trials are required (for example CSIRO rootstocks) establish replicated trials and whole row trials.
- Facilitate national rootstock research forum and work towards national coordination of rootstock research.
- Establish (continue) breeding programs for local conditions rather than relying on importation of rootstocks bred for overseas pests and conditions.

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