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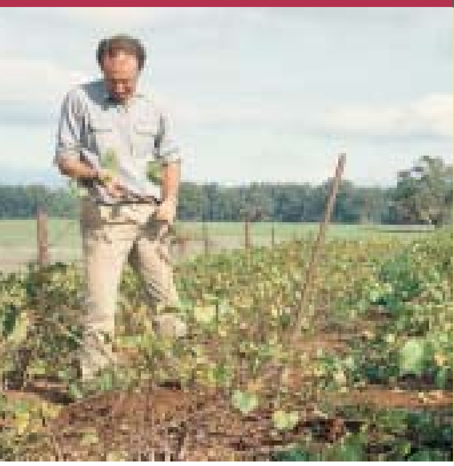

Selection of Grapevine Rootstocks and Clones

For Greater Victoria

Victoria
The Place To Be

Grape and Wine
Research and
Development Corporation

IDC
Greater Victoria Wine Grapes

Preface

Sound knowledge on the use and appropriateness of rootstocks and clones is basic to the long term sustainability and profitability of wine grape growing in Greater Victoria. To make this information readily available and easily accessed by grape growers, the Greater Victoria Wine Grape Industry Development Committee (the IDC) initiated the preparation of this booklet. The IDC is grateful for the co-investment provided by the Grape and Wine Research and Development Corporation, and for the technical expertise provided by the Department of Primary Industries via its Senior Viticulturist, John Whiting, who prepared the booklet.

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Foreword

A Case of "Back to Our Roots" R&D

Those who have worked on this guide to the Selection of Grapevine Rootstocks and Clones have continued the efforts of our country's earliest wine industry researchers.

Pioneers of the industry were quick to recognise the importance of sound planting material to suit Australia's soil types and climatic differences. Their selections were among the first of a large number of research and development inputs that have put this country on a rising plane of performance. Other inputs have come from activities ranging from irrigation technology and vineyard mechanisation to quality management and the determination of flavour compounds in wine.

Within the category of planting material alone there have been several substantial contributions made to the quality of vines since those initial selections. These include plant breeding, recognition of superior clones, matching clones with rootstocks and environment, and selection of rootstocks with tolerance to salinity, waterlogging, drought and disease. The most significant international contribution arguably has been CSIRO's development of DNA profiling technology to provide objective identification of varieties. What is most important to growers, however, is having a choice of clean and reliable clones and rootstocks — and this guide to selection will be extremely valuable in a time of continuing industry development.

The GWRDC are pleased to assist in providing this information to the wine industry in Greater Victoria through the Regional Innovation and Technology Adoption process.

Dr Jim Fortune

Executive Director

Grape and Wine Research and Development Corporation

Grapevine Rootstocks

Background

The practice of grafting is a familiar one in the horticulture industries. The purpose of grafting is to combine the fruiting characteristics of the scion variety with a root system (rootstock), usually from a different species, that is better adapted to the site conditions.

For many centuries, Europe was the centre of wine grape production. The vines cultivated there were based on the 'European' grape, *Vitis vinifera,* that grew wild in the mountainous eastern Mediterranean area. Adventurers exploring the 'new world' of North and South America discovered many new plants, including other species of Vitis grapevine. Live specimens of these new Vitis species were brought back to Europe for botanic collections, nurseries and universities. Unfortunately, the collectors also introduced powdery mildew in 1845 and phylloxera in 1862.

Grape phylloxera is the most destructive insect pest of grapevines. Phylloxera is a root dwelling aphid indigenous to eastern North America, and its native host plants are various American species of Vitis that show some resistance or tolerance to phylloxera. *Vitis vinifera* has little resistance to phylloxera and over 20 years from 1862, phylloxera affected almost all the vineyards in France.

Laliman, an ampelographer from Bordeaux, observed in 1872 that phylloxera did not damage the roots of *Vitis aestivalis*. He argued that, as phylloxera had existed for all time on wild American vines, there must be some quality in these vines that enabled them to resist the attacks of the insect. He was the first to propose grafting of *V. vinifera* onto Vitis species from North America. Thus the grafted vines flourished against the pest and the vineyards of Europe were reconstituted using rootstocks. Further research showed that different rootstocks could adapt to different localities and growing conditions or modify the growing characteristics of the scion, and from that time the usefulness of rootstocks across a wide range of situations has been recognised.

In Australia, phylloxera was first discovered near Geelong in 1877 and later in NSW in 1884. In Victoria it gradually spread up through the central regions to the north east of the state in 1895. Attempts to eradicate phylloxera during this period failed and the only course of action left was to replant with grafted vines. Experience with rootstocks commenced in 1900 in Victoria mainly with selections and hybrids of *V. rupestris* and *V. riparia*.

Ungrafted vineyard at Northwood devastated by phylloxera.

In 1908 the Victorian Government commenced the distribution of bench grafted vines from a nursery at Wahgunyah, near Rutherglen. This was also supplemented at times by direct imports of grafted vines from France. By 1920, almost all the infested vineyards in the proclaimed North-Central Vine Disease District had been replanted with grafted vines (Hardie and Cirami 1988).

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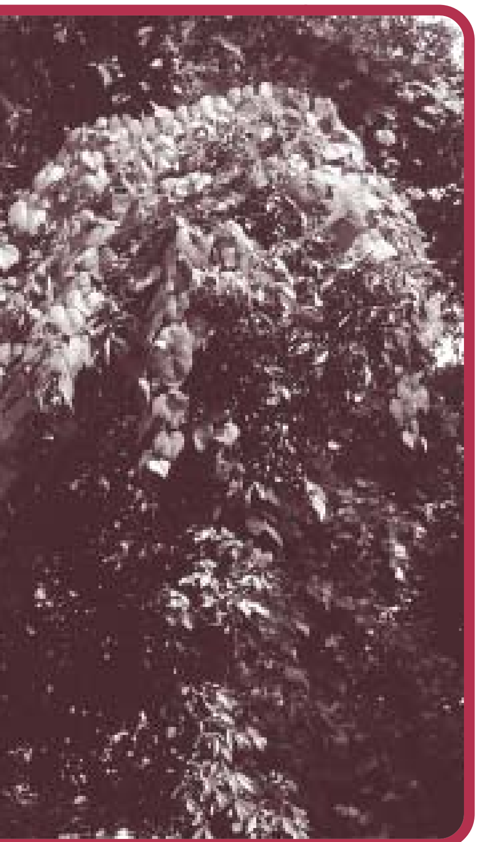
Information on rootstocks suitable for vineyard plantings can help growers decide whether they should use rootstocks and, if so, which ones are likely to provide long term production. It is prudent for growers to be proactive in identifying rootstocks suited to their vineyard sites before a problem such as phylloxera appears. This report provides information for helping determine the rootstocks that may be suitable for your site and document the advantages and disadvantages of a selection of individual rootstocks, incorporating comments on fruit quality implications and specific cultural management practices where available.



North American grapevines growing wild in forest trees.

Vitis Species

There are at least 40 species within Vitis, mostly within the temperate regions of North America. Having developed in the presence of pests and diseases, and under a range of soil and climatic conditions, they show a range of levels of resistance or tolerance to these situations.

During the initial stages of re-planting in Europe, thousands of hectares were planted with American vines but the results were, at first, disappointing. Many vines died before grafting in the field, others survived at first after grafting and then died. But some flourished exceptionally well and yielded heavier crops than had ever been obtained. This resulted in closer attention being paid to the different species and varieties of American vines.

Many mistakes were initially made by using seeds to produce resistant rootstocks. Grapevine seeds are heterozygous and the progeny from seeds has wide genetic variation. This led to hundreds of varieties of *V. riparia, V. rupestris*, etc. being tried, of which some were valuable and many others were useless. The only way to ensure consistent results is to propagate by cuttings from selections or hybrids of Vitis species.

Understanding the basic characteristics of the three main Vitis species used in breeding can assist in the selection of a rootstock where you are unsure of what to use.

The first rootstocks used against phylloxera were varieties of a single species: eg. *Vitis rupestris*, variety Rupestris du Lot; and *Vitis riparia*, variety Gloire de Montpellier. It was soon found advantageous to use hybrids (breeding 2 or more varieties) of the American species to combine their desirable features:

eg. tolerance of moist conditions (*V. riparia*)
tolerance of dry conditions (*V. rupestris*)
tolerance of calcareous soil (*V. berlandieri*).

Other species have been incorporated into rootstocks, but the three species mentioned have proved to be the most important.

Some rootstocks have had *V. vinifera* in their parentage. These particular rootstocks are only used in exceptional circumstances. For example in France where soils have a very high lime content, eg. in Champagne, 41B and 333 EM are used. Rootstocks with *V. vinifera* parentage should not be used where good phylloxera resistance is required. Soils in Australia generally do not require rootstocks with such high lime tolerance as 41B, 333EM or Fercal.

Species Characteristics

Understanding the basic characteristics of the three main Vitis species used in breeding can assist in the selection of a rootstock where you are unsure of what to use. By combining the characteristics of hybrids a wide range of situations can be catered for.

Vitis Rupestris

This species commonly occurs in stony soils in south-western Texas, extending northward and eastward to New Mexico, Indiana, Tennessee and Pennsylvania. Its favourite places are gravelly banks of mountain streams. It requires a deep soil and penetrable subsoil. In shallow dry soil it will suffer from drought. It flourishes in excessive heat or cold. Cuttings root very easily and graft well but roots are very sensitive to some root-rotting fungi and should not be planted where the water table is high through the growing season.

V. rupestris is quite resistant to phylloxera although its rootlets can show nodosities (galling) but rarely galling on thicker roots (which is considered to debilitate the vine). The leaves support the leaf galling form of phylloxera. It has some sensitivity to lime induced chlorosis. The growing cycle of *V. rupestris* is relatively long.

Vitis Riparia

Of all American *Vitis* species this has the greatest geographical range. It extends from the centre of Canada in the north, to Texas and Louisiana in the south and west to the Rocky Mountains. In its natural habitat it grows on river banks in deep, moist, fertile soils. It prefers cool, naturally fertile, deep soils, well supplied with water and tolerates cold conditions well. It does not do well in calcareous or drought prone soils. In dry, sandy soils it has only weak development.

Cuttings root very easily and graft well. Vines grafted to *V. riparia* regularly give good crops, ripen their fruit early and develop a high sugar content. It was used on up to 75% of the vineyards replanted in France. The root system is highly resistant to phylloxera, but the leaves often carry the galls. The species has a short growing season.

Vitis Berlandieri

A native of the limestone hills of south west Texas this species is also found in the south of New Mexico and north Mexico. It is a species for hot climates, with some drought tolerance. It is highly resistant to phylloxera but supports some leaf galls. *V. berlandieri* has excellent affinity with *V. vinifera* and aids the fertility of grafted vines.

Of all American Vitis species it is most resistant to lime-induced chlorosis. However cuttings root with some difficulty and for this reason it is not used commercially as a single species but as hybrids with easy rooting V. *riparia* or V. *rupestris*. It has a relatively long growing cycle

Other Species Used as Rootstocks

Vitis Champini

Possibly a natural hybrid between *V. rupestris* and *V. candicans*, it occurs in their overlapping natural habitats. It is vigorous, resistant to nematodes and phylloxera, and tolerant to limey soils. Cuttings tend to root with some difficulty.

Characteristics of Common Hybrid Rootstocks

Since the single Vitis species described above often had desirable and undesirable characteristics, cross breeding was implemented in an attempt to combine the desirable characteristics with as little as possible of the undesirable traits. Of the many hybrids attempted, most of the better results came from some specific crosses described below.

V. riparia x V. rupestris crosses

Based on the excellent cultural characteristics of the two species, it was expected that hybrids would lead to high quality rootstocks. Rootstocks of this type expanded rapidly in every viticultural country and were highly praised in the beginning. They are particularly noted for quality wine production. They confer low to moderate vigour to scions and have relatively low drought tolerance. They have good phylloxera resistance and some have good nematode resistance. Examples include:

3309 and 3306 Couderc

101-14

Schwarzmann.

In France, however, their use is decreasing in favour *of V. berlandieri x V. riparia* crosses, which have a superior adaptive spectrum.

V. berlandieri x *V. riparia* crosses

These hybrids have good phylloxera resistance, some nematode resistance, good lime resistance and good affinity with vinifera. Some crosses are more tolerant of drought compared to *V. riparia x V. rupestris* hybrids. They confer moderate to high vigour to the scion and are suited to cool climate, quality wine areas due to their earliness of maturity and moderate vigour. Examples include:

SO 4

5BB Kober/5A Teleki

5C Teleki

420A Millardet and de Grasset.

V. berlandieri x *V. rupestris* crosses

Rootstocks in this group are vigorous, often very resistant to drought and are best adapted to warm regions. They have high phylloxera resistance, some nematode resistance and tolerate limey soils. They have a long vegetative cycle and are less adequate in cooler climate areas. They can adapt to poor growing conditions, infertile soils, and drought. Examples include:

1103 Paulsen

99 Richter

110 Richter

140 Ruggeri.

... cross breeding was implemented in an attempt to combine the desirable characteristics with as little as possible of the undesirable traits.

Consider using rootstocks:

- *when there is a risk of phylloxera infestation*
- *when nematodes are present in the soil*
- *in replant situations*
- *in drought prone soils*
- *in saline soils*

Other hybrid rootstocks used in Australia

A number of other Vitis hybrids have been used in the past or have recently become available. Some of these include:

V. vinifera x *V. berlandieri*,
eg. 333EM, 41B.

V. vinifera x *V. rupestris*,
eg. 1202 Couderc, ARG No 1.

V. champini x *V. rupestris*, *V. champini* x *V. riparia*, *V. champini* x *V. vinifera*,
eg. Lider's K and J series.

(*V. vinifera* x 333EM) x *V. berlandieri*,
eg. Fercal.

V. longii x (*V. labrusca* x *V riparia*) x *V. vinifera*,
eg. 1613 Couderc

Dogridge x 1613 Couderc,
eg. Harmony, Freedom.

Selecting Rootstocks

In the past, most grape growers outside the phylloxera zones have planted vines on their own roots. This practice has been a cheaper way to establish vineyards compared to using grafted vines. In replant situations, however, especially in sandy, nematode infested soils, growers will need to use rootstocks. Also other particular situations (saline soils, saline irrigation water, soils prone to drought, and the provision of added or reduced vigour, etc.) will require consideration of rootstocks. An extensive summary of Australian research on the adaptation of rootstocks to environmental conditions is provided in May 1994.

Growers learning about assessing soil conditions.

A panel of ungrafted vines in a rootstock trial infested with phylloxera.

When planning to use rootstocks, the primary consideration should be to only use rootstocks with a **high level of phylloxera resistance**. Phylloxera is a devastating pest of grapevines and if growers are going to the expense of planting on rootstock, then it is crucial to only use rootstocks that are resistant to phylloxera. For this reason, **any rootstock with *V. vinifera* in its parentage should be avoided** (eg. 1202 Couderc, 1613 Couderc, 41 B Millardet et de Grasset, 333 Ecole de Montpellier, Fercal, ARG No 1 (AXR 1)). It is only in exceptional circumstances that a rootstock of low resistance would be considered, eg. in very limey soils similar to the Champagne region in France

Anther issue that has emerged recently is that particular clones of phylloxera (formerly called biotypes) are associated with certain rootstocks. These phylloxera will attack 'resistant' rootstocks and produce nodosities (galls on the feeder roots). However it is rare for tuberosities (galling on thicker storage roots) to be formed, and the rootstock continues to survive the phylloxera attack. Under extreme stress conditions, the galling of feeder roots may have an impact on rootstock performance, such as has been demonstrated in Germany with 5C Teleki on shallow soils under dry conditions. Further research on this issue is required but in the mean time it would be worth avoiding a combination of rootstock and phylloxera clone that is known to promote galling on feeder roots.

The choice of a rootstock for any particular location will depend on the complex interactions between soil type, soil depth, physical and chemical properties of the soil, availability of water, environmental factors, pests, and diseases. **Where soil factors are not optimum, then they should be remedied prior to planting – a rootstock will not perform at its best in a poor soil situation.** For example, acid soils should be limed prior to planting, nutrient deficiencies should be corrected, excessively wet soils should be drained or 'hilled-up' to allow the vine roots to remain above water, dry soils should be provided with irrigation and saline soils should be treated to reduce salt loads.

There will never be a single 'universal' rootstock that will suit all situations, and it is more likely a range of rootstocks will be suited to a variety of conditions. For any particular site there will generally be several rootstocks that can be selected for establishment. In the absence of physical or biological stress in a vineyard, ungrafted *V. vinifera* often perform as well as any rootstock. Where it is not clear that a rootstock will provide a performance advantage, the decision to plant on rootstock is then based on an assessment of the risk of developing a stress situation, such as phylloxera or drought.

Assessment of Resistant Rootstocks

Grapegrowers should undertake rootstock assessment on each of the major soil types in the vineyard since it is the adaptation of the rootstock system to the site that is the main consideration. However there are also interactions with the scion varieties, and with the management systems being used. In other words do not expect all rootstocks to react exactly the same across a vineyard.

Each rootstock has their own characteristics when it comes to water use, growth, nutrient uptake, salinity tolerance, etc., and each rootstock/scion combination needs to be managed accordingly. In the past many rootstocks have been managed just like ungrafted vines and have not performed well, ie. they have been too vigorous or the fruit quality has been poor.

Given the limited resources available it is not possible to evaluate rootstocks for all combinations of scions and site conditions. At best, some guidelines can be determined to narrow down the range of rootstocks to select from. The ultimate assessment of the rootstocks and the 'fine tuning' needed to identify the best rootstocks for each vineyard block must, however, rest with the individual grapegrower.

General Comments on Wine Quality and Rootstock Vigour

It is generally agreed that to obtain the best fruit quality, excessive vigour must be avoided. The best regarded wines of the world are generally produced from low to moderate vigour vineyards where there is a balance between the shoot and fruit growth, and the fruit receives appropriate exposure to light. It is very difficult to attain the correct vine balance when using vigorous rootstocks in fertile soils. Vigorous vines grown on vigorous rootstocks will have delayed maturity and poor fruit quality. Even with extensive trellis modification it becomes difficult to consistently meet quality specifications and impractical to manage.

Some early published trial results highlighted concerns about rootstocks producing quality grapes. However this work used combinations of rootstocks and scions that were un-balanced. When the rootstock/scion/site combination is appropriate there is little impact of rootstock on fruit quality.

In rootstock trials where vines are under stress (environmental or pest), it is often the ungrafted vines that suffer most. In a number of trials where wine colour has been measured (high wine colour has been associated with higher wine quality), grafted vines have produced higher colour levels than ungrafted vines.

Incompatibility Issues

In the past there have been numerous reports of problems with grafting and subsequent growth of rootstock/scion combinations. These were often described as incompatibility but were probably also confused with affinity. In simplistic terms compatibility refers to the ability of the rootstock and scion to combine anatomically and physiologically after grafting to produce a thriving grafted plant. Affinity on the other hand refers to the longer-term productive capacity of the grafted combination.

In earlier times, incompatibilities were often unexplained, despite indexing for virus content. Rootstocks are often symptomless carriers of

Poor Set can sometimes be improved by rootstocks.

For any particular site there will generally be several rootstocks that can be selected for establishment.

Poor graft union similar to that of fungal infected vines.

virus and it is only when the scion is grafted to the rootstock that problems are expressed (see further discussion of viruses under the clonal section of this publication). Indexing is useful for detecting a general class of virus, eg. leaf roll virus, but recent developments with gene technology have now shown that there are at least nine types of leaf roll virus, many with varying levels of impact on grapevines.

What the gene technology techniques also show is the extent of combinations of viruses not detected with earlier indexing techniques. Some grafted vine combinations include rupestris stem pitting associated virus, grapevine fleck virus, grapevine viti virus A, and grapevine leafroll (Habili and Symons 2001). Some of these vines have had symptoms of reduced vigour and vine decline similar to incompatibility symptoms.

In addition, recent research has elucidated the cause of 'young vine decline'. The decline is named Petri disease (was known as black goo decline) and is associated with a fungus *Phaeomoniella chlamydospora* (previously known as *Phaeoacremonium chlamydosporum*) (Edwards and Pascoe 2002). The symptoms described for this disease are similar to those described for incompatibilities in the past. Other fungi have also been implicated in vine decline, some of which are yet to be described.

Many of the incompatibility problems described in the past may have been associated with virus or fungal diseases, which were unidentified at the time. There are also inconsistencies between the performance of some rootstocks in trials in the 1970's and 1980's (using material from then recently introduced rootstocks) and recent performance. For example 101-14 showed no incompatibility problems in trials at Loxton established in 1983 yet problems with 101-14 and particular scion combinations have been reported (Furkaliev 1996) since. It may be that levels of virus or fungi have developed in rootstock source blocks over time.

It is crucial to use virus and fungal tested planting material to avoid these potential problems. State vine improvement associations hold information relating to the 'health' of their source blocks. Growers are advised to use propagating material that can be traced (without the potential for contamination) to a known tested origin.

Charactistics of Commonly Used Rootstocks

Many of the characteristics mentioned below, are described in terms relative to other rootstocks. The difficulty of using definitive measures is that the rootstocks have been tested across a range of sites with varying levels of capacity for vine growth. For example in deep, fertile, moist soils almost all rootstocks have the capacity for vigorous growth, yet in shallow, dry soils only certain rootstocks maintain that relative vigour.

As with scion varieties, there are different selections (clones) of rootstocks. No trial work in Australia has established the affect of using different selections of the one type of rootstock. The nearest has been the comparison of 5BB Kober and a selection of 5BB introduced as 5A Teleki. Genetic techniques have shown they are in fact the same rootstock (5BB Kober) hence where 5A Teleki and 5BB are compared in trials it could be considered a clonal comparison. The clonal identity of many rootstocks is listed in the National Register of Grapevine Varieties and Clones (deLaine and Nicholas 2000) available from Winetitles, Adelaide, (www.winetitles.com.au). Growers should record all details provided by the nursery (nurseries should identify the source of material used in propagation) when they plant their vineyard.

3309 Couderc

- *Low to moderate vigour*
- *Moderate to good yields*
- *For deep, well drained soils*
- *Not for dry, shallow soils, unless well supplied with irrigation*
- *Consistently lower juice pH*
- *Not for saline soils*

3309 Couderc (*V. riparia x V. rupestris*)

This rootstock is used extensively in the north east of USA (New York State) but not to any extent now in Australia. It was one of the common rootstocks used for the reconstitution of phylloxera affected vineyards in the early 1900's in north east Victoria.

According to Cirami (1999), the rootstock has low to moderate vigour, is suited for varieties with poor fruit set, it advances fruit maturity, and it is suited to deep, well-drained soils in a cool climate that are well supplied with water. It is not suitable for dry and shallow conditions, not appropriate for heavy soils, has a moderate tolerance to limey soil, and does not tolerate saline soils well. It has a tendency to induce potassium deficiency in overcropped young vines on clay soils. Young vines grafted to 3309 can be very nutrient demanding. It has high resistance to phylloxera, but is susceptible to nematodes. It is resistant to crown gall and susceptible to phytophthora. Easy to root and graft. It is being replaced by SO4 in Burgundy.

The rootstock 3309 has only been used in a couple of recent trials in Victoria (tables 9 and 18) where it shows moderate vigour with moderately good yields. The rootstock has recorded a consistently lower juice pH, but did not significantly advance maturity or improve berry number per bunch on Chardonnay or Pinot Noir. It takes up greater amounts of chloride than other rootstocks. Performed satisfactorily in a sandy clay loam (brown dermosol) as well as a shallow duplex soil. It has high phylloxera resistance and resistance to nematodes varies depending on the species involved.

Another Couderc hybrid, 3306, has similar characteristics to 3309, but is reputed to be better suited to wetter, fine textured soils than 3309. It has only been tested in 2 trials (tables 17 and 18), both with duplex soils, where it performed mostly mid range for the characteristics assessed, except for a relatively lower berry weight.

101-14 (*V. riparia x V. rupestris*)

This rootstock is used in South Africa and parts of France. It did not find favour in the reconstitution of vineyards in north east Victoria in the early 1900's as similar hybrids 3309 and 3306 performed better in that region.

Cirami (1999) reports that in the Riverland of SA, 101-14 has moderate vigour and has produced high yields of both red and white varieties in trials. He also reports that it improves fruit set, advances grape maturity, does not appear to have a higher juice potassium or pH, and has higher colour than other medium to high yielding rootstocks. It has a fairly shallow, well-branched root system, and requires moist, deep soils, and has moderate resistance to lime in the soil. Cirami also states it should not be used in acid soils without prior pH adjustment, it is resistant to high soil salinity and to spring waterlogging.

In Greater Victoria it has only produced moderate yields (tables 11, 12, 16 and 19), similar to its performance in areas outside the Riverland of SA. It is a moderate vigour rootstock that consistently produces moderate yields with satisfactory grape composition. In one trial on a poorly structured sodic soil, 101-14 had poor growth and yield (table 16). Across the trials, it generally had high sugar levels at harvest although this may relate to the relatively moderate yield.

In contrast to Cirami (1999), the higher sugar levels in the Greater Victoria trials were associated with higher pH levels in the juice. Also 101-14 did not tolerate spring waterlogging in one trial in a clay loam soil, as it died out during establishment in a wet spring. This is similar to experiences with 101-14 back in the early 1900's in Victoria. There has been no consistent affect on berry number per bunch in the Greater Victoria trials.

It is resistant to phylloxera and moderately resistant to nematodes. It is considered easy to graft and root.

Cirami (1999) reports some particular problems with incompatibility and lack of affinity with 101-14. No sign of such problems have been observed in the DPI trials nor in long term plantings in the Riverland. Growers using 101-14 should ensure the health status of grafting material before committing to using this rootstock (see section on incompatibilities above).

Schwarzmann (*V. riparia x V. rupestris*)

Schwarzmann is not a rootstock used overseas so there is little comparative information available. It has been widely used in table, dried and wine grapes, particularly in Western Australia and in Victoria. It has only been in recent years that Schwarzmann has been knocked out of second place behind Ramsey in the annual cutting sales by state vine improvement associations.

Some of the attributes ascribed to this rootstock by Cirami (1999) include moderate vigour, improved fruit set, high yield, and more tolerance to limey soils than other *V. riparia x V. rupestris* hybrids. It does not effect maturity rates.

In Greater Victoria, Schwarzmann has been extensively planted mainly because it was

101-14

- ***Moderate vigour***
- ***Relatively high yields in deep soils in hot irrigated areas***
- ***Moderate yields in cooler areas with shallow soil***
- ***Relatively higher sugar levels and pH at harvest***
- ***Not for poor, sodic soils or for waterlogged soils***
- ***Not for dry, shallow soils without adequate irrigation***

Schwarzmann

- ***Moderate vigour***
- ***Moderate yields under good growing conditions***
- ***Poor yields in dry, conditions***
- ***Higher berries per bunch***
- ***Advances maturity under good conditions***
- ***Juice pH higher due to higher juice potassium***
- ***Withstands waterlogging better than other rootstocks***

Rootstock source block.

regarded as reasonably adaptable to a range of conditions and it was readily available and grafted easily. It has been tested in many of the trials listed in the tables in the appendix (tables 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 13, 14, 15, 17, 18, and 20).

In the DPI trials, Schwarzmann has moderate vigour, but in drought prone situations it has low vigour. It has rarely been a high yielding rootstock in trials and usually has moderate yields under good growing conditions. In dry conditions it has low yields. It has consistently higher berry number per bunch than other rootstocks perhaps through improving fruit set. The berry weight tends to be lower than other rootstocks. It also appears to advance maturity (°Brix) in many trials compared with other rootstocks at similar cropping levels. However under dry stress conditions it has low sugar even at low yields (see table 8).

The juice pH of Schwarzmann is higher than other rootstocks at similar sugar levels in a number of trials. In a few trials, where it has been measured, the higher pH has been associated with higher juice potassium. The rootstock also has higher potassium in the petioles than most other rootstocks in Greater Victoria. It has a lower petiole chloride than ungrafted *V. vinifera* and rates similar to other rootstocks reputed to tolerate salinity.

Schwarzmann does best on deep, moist soils and should **not** be used where summer drought is common or where moderate to high water stress is generated to manipulate grape quality.

Schwarzmann has high resistance to phylloxera and to nematodes, and is easy to propagate.

SO 4

- *Moderate to high vigour*
- *High yields*
- *Moderate to high berry weight*
- *Low juice pH*
- *Avoid using in deep, fertile, humid soils*
- *Ensure adequate irrigation if used in dry, shallow soils*

SO 4 (*V. berlandieri x V. riparia*)

This rootstock is used extensively in Germany, France and to a lesser extent other European countries. It has not 'taken off' in 'new world' countries although it has been tried in South Africa and Canada.

A rootstock imported to Australia in 1966 from the University of California as 'SO4' was later identified as 5C Teleki. A similar problem occurred in the New York State plantings of 'SO4'. True SO4 has only been used in trials since about 1985, and even since then some confusion over the identity of the rootstock has remained. Where early rootstock trials named 'SO4' it should rightly be reinterpreted as 5C Teleki.

Cirami (1999) summarised its characteristics as being moderately vigorous to vigorous, suited for varieties with poor set and advances maturity. However French experience is to the converse, ie. its excessive vigour causes poor fruit set and SO4 delays maturity. In France SO4 favours the development of Botrytis in autumn due to excessive growth. The French also report that vine vigour decreases drastically after 15-20 years. SO4 has a shallow growing root system, it tolerates high levels of lime, and performs satisfactorily in acid soils. It is well adapted to a wide range of soils, but does best in light, well-drained soils of low fertility with adequate humidity, but it is not recommended for dry conditions. It assimilates magnesium poorly and when grafted with Merlot or Cabernet Sauvignon, it induces inflorescence necrosis. It is susceptible to tyloses, a physiological disorder that induces a sudden wilting of leaves in dry seasons.

SO4 has only been tested in a couple of trials in Greater Victoria (tables 8 and 21). In those trials it has high vigour, despite the soils being allowed to dry down. It has high yields and tends to have a moderate to high berry weight with a consistently low juice pH. SO4 has high phylloxera resistance, and good resistance to a range of nematodes. There has been an inconsistent effect on berry number per bunch; in one trial with Cabernet sauvignon SO4 was lowest and in another trial with Shiraz, SO4 was highest.

It roots well, but results of bench grafting are sometimes disappointing. Evidence would suggest it would be excessively vigorous in deep, fertile, humid soils.

5BB Kober /5A Teleki
(*V. berlandieri x V. riparia*)

5BB Kober was an early rootstock selected in 1904 by F. Kober of Austria from a batch of seedlings raised by S. Teleki of Hungary. It is widely grown in Germany and Switzerland and to a lesser extent in other European countries.

The University of California recently determined that the 5A Teleki rootstock variety in their collection (Foundation Block), which was supplied to Australia in 1966, is the same as 5BB Kober. The two rootstocks in Australia have also been tested by CSIRO using 'genetic fingerprinting' and appear to be identical. They do, however, seem to have some clonal differences, and each 'clone' should be kept separate. In the trials in Greater Victoria, significant differences between 5A Teleki and 5BB Kober were apparent in 3 out of 6 trials, primarily for yield and bunch number per vine (tables 1, 10 and 20). 5BB Kober will be used here as the identifying name for both clones.

Cirami (1999) has described 5BB Kober as having moderate to high growth and yield in irrigated areas, with a short vegetative cycle. It has a shallow root system, tolerates high lime in the soil, has no salt tolerance and is one of the best rootstocks for humid, compact, calcareous soils. It is sensitive to Phytophthora, and not recommended for sites prone to standing water. It is susceptible to tyloses. It has yielded as well as many other rootstocks apart from Ramsey in trials across numerous sites in South Australia.

5BB Kober or '5A Teleki' have been planted in most trials in Greater Victoria (tables 1, 3, 4, 5, 6, 7, 9, 10, 12, 14, 15, 16, 17, 19 and 20). In trials at Wahgunyah, Victoria (deep sands and sandy loam soils with nematodes and phylloxera), 5BB Kober/5A Teleki were among the highest yielding rootstocks with Chardonnay and Shiraz as scions. In most other trials it produced moderate to high yields, with an exception on the Mornington Peninsula (table 17). Even in a trial in shallow, dry, duplex soils, 5BB Kober has performed at least moderately well (table 1).

5BB Kober has consistently produced moderate to high berry weights and has moderate to high sugar levels despite some high yields. Whilst it has been reported to lack salt tolerance by Cirami (1999), the petiole chloride and sodium was rated similar to other salt excluding rootstocks, and far lower than ungrafted *V. vinifera*. In addition, the petiole potassium concentrations were significantly less than Schwarzmann in 6 out of 7 trials where they were compared.

It has very good resistance to phylloxera and moderate to high resistance to nematodes. 5BB Kober roots and grafts well. There have been reports of incompatibility with Chardonnay in Victoria. Recent research suggests that certainly some of the graft and young vine failure may be due to *Phaeomoniella chlamydospora* (Petri Disease, Black Goo).

5C Teleki (*V. berlandieri x V. riparia*)

This rootstock is used in Germany where it has a reputation for ripening earlier than other *V. berlandieri x V. riparia* hybrids. Not used in Australia until inadvertently introduced as 'SO4' from California (see SO4 section).

According to Cirami (1999), the rootstock has moderate vigour (less than 5BB Kober and SO4), it is good for varieties with poor set, it advances maturity, it is suited to well drained fertile soils and is good for clay and clay loam soils. It has performed very well in sandy soils under nematode pressure in Barossa and McLaren Vale, as well as doing well in Clare and Langhorne Creek.

In Greater Victoria, 5C Teleki has moderate vigour and it has moderate to high yields across many trials (tables 2, 3, 4, 5, 6, 9, 10, 12, 13, and 20). It yielded poorly in one trial which was unirrigated in a shallow, sandy duplex soil (table 1). It has had no consistent impact on berry number per bunch across the trials in Greater

5BB Kober /5A Teleki

- ***Relatively high vigour in deep soils***
- ***Generally a moderate to high yielding rootstock across a wide range of sites***
- ***May produce larger berries than other stocks***
- ***Sensitive to Phytophthora root rot in poorly drained soils***
- ***Avoid sites likely to induce high vigour***

5C Teleki

- ***Moderate vigour***
- ***Moderate to good yields across many sites***
- ***Tends to produce larger berry weights***
- ***Avoid growing in shallow, dry soils***

Avoid scion rooting on grafted vines - do not cover the graft union with soil.

Victoria. 5C Teleki did not consistently advance maturity across a range of scions and sites in Greater Victoria, but it did tend to produce larger berry weights than other stocks. 5C Teleki has moderate drought resistance and high tolerance to calcareous soils.

5C Teleki normally has good phylloxera resistance and good nematode resistance. However in Germany, 5C Teleki has suffered under the combined effects of phylloxera and drought in shallow soils. It roots and grafts well.

420A Millardet and de Grasset (*V. berlandieri x V. riparia*)

420A Millardet and de Grasset

- *Low to medium vigour*
- *Low to moderate yields*
- *Does not like waterlogging*
- *Needs further testing*

420A was a very early hybrid rootstock and it has been grown widely in the past in areas of France, Italy and South Africa. It was used as one of the main rootstocks during vineyard reconstitution in Victoria in the early 1900's. More recently it has been superseded by other rootstocks.

Information provided by Cirami (1999) describes 420A as low to medium vigour, it improves scion fertility, has a long vegetative cycle and it has a shallow growing and well-branched root system that is well suited to poorer, heavy textured soils. It is susceptible to drought, does not like waterlogging, has good lime resistance but is prone to potassium deficiency. Vines grow very slowly and have a tendency to overcrop in the early years of vine development.

The rootstock has generally had low to moderate vigour and yield in trials in Victoria (tables 2, 3 and 18) but in one trial with Chardonnay it yielded well (table 11). Despite the low yields in most trials, it has not had high juice sugar levels, and tends to have low juice pH. It requires further testing before it could be recommended for wider use.

It has high phylloxera resistance, with moderate nematode resistance. 420A is susceptible to Phytophthora. It does not root or graft easily, and has been reported to have poor affinity and incompatibility with a number of varieties overseas.

1103 Paulsen (*V. berlandieri x V. rupestris*)

1103 Paulsen

- *Low to medium vigour*
- *Relatively low yield*
- *Has fewer berries per bunch than other stocks*
- *Needs to be more widely evaluated*

Was bred in Sicily and widely planted in Tunisia, southern parts of Italy and France and north Africa. Imported into Australia in 1980 hence experience with it is rather limited.

According to Cirami (1999) the rootstock is moderate to vigourous in growth, it has a deep growing, strongly developed root system and is reported to be more drought tolerant than 110 Richter and 140 Ruggeri in Sicily and Algeria. In calcareous soils in France it performs better than 99 Richter, but not as well as 110 Richter, it does well in acid soils and it has moderate tolerance to salt. It is reputed to have a long vegetative cycle and delays maturity of the scion. It has performed exceptionally well in the Barossa Valley.

In Greater Victoria, trials with 1103 Paulsen in a range of situations show this rootstock has low to moderate vigour with consistently low yields (tables 8, 11 and 21). The lower vigour contrasts with overseas experience and Cirami 1999. It has consistently fewer berries per bunch and relatively low or medium berry weights. It should be more widely assessed throughout Victoria.

1103 Paulsen has high resistance to phylloxera, and moderate resistance to nematodes. It roots and grafts well.

99 Richter (*V. berlandieri x V. rupestris*)

99 Richter

- *Moderate to high vigour*
- *Moderate to high yields*
- *Suited to a wide range of soils*
- *Not suited to wet, poorly drained soils*
- *Good drought tolerance*

This rootstock is used in the warmer, drier regions of southern France and northern Africa. It has also been widely grown in South Africa and it was the best performing rootstock in a long-term rootstock trial at Wahgunyah, Victoria. A selection of 99 Richter imported from California (Accession No. IV642083) actually turned out to be 110 Richter (Hardie et al. 1981), so some care needs to be made in interpreting the identity of '99 Richter' in some trials reported between the late 1960's and the early 1980's.

Cirami (1999) reports that 99 Richter is quite vigorous, and can delay fruit ripening, but it has a short vegetative cycle and can be grown under cool conditions. It has a strongly developed root system, which is very deep growing. 99 Richter is well suited to a wide range of soils, but not wet, poorly drained conditions. It is drought tolerant and performs well in acid soils, but under very dry conditions, it is not as effective as 110 Richter. It does not tolerate salt but does tolerate high levels of lime. It has performed well in the Barossa Valley.

99 Richter has been tested in a number of trials in Greater Victoria (tables 5, 6, 13, 15, 16, 17 and 21). It has always yielded moderately well to high across a range of sites, from dry, duplex soils to wetter, acidic soils. It has shown to be of medium to high vigour in all sites and is reputed to be high to very high vigour in deep, moist soils. In poorly drained soils it is susceptible to root rot, eg. *Phytophthora cinnamomi*. In trials in Greater Victoria it did not consistently delay maturity and, in one trial, the petiole chloride concentration was similar to other salt tolerant rootstocks.

It has a high resistance to phylloxera and to nematodes. Its rooting ability is fair and it grafts well (however the French report less successful results with bench grafting).

110 Richter (*V. berlandieri x V. rupestris*)

This rootstock is used more widely than 99 Richter in Spain, France, Greece, Turkey and north Africa in the warmer, drier areas. It has been a popular rootstock for replanting phylloxera affected ARG No.1 in California.

Information collated by Cirami (1999) describes 110 Richter as a moderate to vigorous rootstock, with a long vegetative cycle, delayed fruit maturity, and not being appropriate for varieties with irregular set. The root system is not as deep growing as 99 Richter, and 110 Richter is well suited to all kinds of soils, including acid soils. Its resistance to drought is better than 99 Richter and it does well on badly drained, shallow clay soils. In McLaren Vale and the Barossa Valley it is performing quite well with manageable growth.

In Greater Victoria, 110 Richter has consistently low to moderate vigour, and is one of the few rootstocks to have relatively low vigour in deep, moist soils (tables 1, 2, 3, 4, 6, 9, 10, 11, 12, 14, 17, 18 and 20). This contrasts with experiences elsewhere where 110 Richter is described as a vigorous rootstock. The lower vigour is associated with comparatively lower yields and, even with the relatively low yields, it does not produce high sugar levels at harvest. It consistently has low juice pH and low juice potassium in our trials. The sodium and chloride concentrations in the petioles are quite low suggesting it may tolerate saline conditions better than some other rootstocks.

The rootstock is highly resistant to phylloxera and moderately resistant to nematodes. It does not root and graft as well as other rootstocks. Initial vine growth can be slow as it develops a root system.

DPI rootstock trial site.

140 Ruggeri (*V. berlandieri x V. rupestris*)

This rootstock was bred in Sicily and widely used in other Mediterranean countries, Italy and north Africa. It has more recently gained acceptance in the south of France. First imported into Australia in 1974, so experience with it is relatively limited.

It is described by Cirami (1999) as being of similar vigour and yield to Ramsey, but it has been reported to have reduced colour similar to Ramsey. It may be safer to use for red varieties, and should be a good rootstock for use in premium white wine production. The root system is very deep-growing, and well branched. 140 Ruggeri is considered resistant to high soil salinity but is moderately susceptible to spring soil waterlogging. The rootstock performs well in shallow, dry, calcareous soils, and is very drought tolerant. It is well adapted to acid soils. It grafts well, but is not easy to root.

140 Ruggeri has displayed moderate to high vigour in Greater Victoria across a range of sites. Yields are largely moderate to high (tables 6, 8, 11 and 16) but in one trial the yield was low (table 9). The rootstock produces medium size berries with moderate to high juice pH relative to other rootstocks. In one trial it has a low petiole chloride level reflecting its tolerance of saline soils.

It is resistant to phylloxera and moderately resistant to nematodes.

110 Richter

- *Low vigour in Victorian trials across a wide range of soils and site conditions*
- *Low to medium yields*
- *Low juice pH and potassium*
- *Good drought tolerance*

140 Ruggeri

- *Relatively high vigour*
- *Mostly good yields*
- *Good drought tolerance*
- *Not for use in deep, fertile soils*
- *Good for saline soils*

Ramsey

- *High vigour in deep, sandy soils*
- *Moderate vigour in dry, shallow soils*
- *Moderate to high yielding rootstock*
- *Lower sugar levels at harvest with low juice pH*
- *Sometimes results in poor colour where vines are vigorous*
- *Not as good as other rootstocks in saline soils*

Ramsey (*V. champini*)

Not a rootstock used by 'Old World' countries. Has found favour in California, South Africa and Australia primarily for nematode resistance. *V. champini* appears to be a hybrid of *V. candicans x V. rupestris*. Ramsey was introduced to Australia from California as 'Salt Creek', but the real Salt Creek is a *V. doaniana* selection not used commercially. Dog Ridge is another *V. champini* selection used in hot, irrigated regions. It has greater vigour than Ramsey, takes up high amounts of potassium, and is primarily used in low fertility sands. It has not been considered in any trials in Greater Victoria.

Cirami (1999) has summarised the characteristics of Ramsey. He reported that the rootstock produces more fruit and growth than most other stocks. In deep, sandy soils, the excess vigour can delay maturity, cause excess potassium uptake and affect wine quality, and may cause declining production through reduced bud fruitfulness and fruit set. There have been problems with red varieties grown on Ramsey where there is less colour (anthocyanins) and reduced phenolics in the grape juices and resultant wines.

Ramsey has been tested in a wide range of situations in Greater Victoria (tables 1, 2, 3, 4, 5, 6, 7, 9, 11, 12, 15, 16, 17 and 19). In Greater Victoria, in finer textured clay loam, duplex soils, Ramsey produces moderate to high vigour, which is usually manageable. However in deep, sandy soils it is capable of producing large canopies with its high vigour, although it does not produce the excessive vigour reported in hot irrigated areas. Perhaps the heavier soils and cooler conditions contain the growth of Ramsey.

It is mostly a moderate to high yielding rootstock and has never been low yielding. It tends to have lower sugar levels at harvest but it is not clear whether this is due to the heavier crops or a lesser capacity to ripen the fruit. Other rootstocks at similar yield levels usually produce fruit with more sugar at harvest. Ramsey produces a medium to high berry number per bunch with a generally medium berry weight. Ramsey also produces a relatively low juice pH in most trials which is in direct contrast to results from hot, irrigated areas. In some instances in Greater Victoria, Ramsey has produced wines with higher colour levels than ungrafted vines, where ungrafted vines have suffered from water stress.

Ramsey is reputedly moderately susceptible to spring waterlogging. It is very resistant to nematodes and has good resistance to phylloxera. Ramsey is considered very tolerant to high soil salinity. However in five trials in Greater Victoria, petiole chloride was higher in Ramsey than other high saline tolerant rootstocks such as 140 Ruggeri or 110 Richter, but less than rootstocks with *V. vinifera* in their parentage.

Rootstocks for Further Evaluation

Teleki 'C' is a rootstock of unclear origins. It was sourced from the old variety collection at the Department of Primary Industries Rutherglen. It appears to be a *V. berlandieri x V. riparia* hybrid. It has been tested in two trials (tables 8 and 16), both with some degree of stress on the vines. In these cases it showed good growth and high yields. Appears suited for poor soil situations, and worthy of further broader evaluation.

Riparia Gloire (*V. riparia*) has been successfully used in the past in deep, moist, fertile loams with good drainage. In recent trials performance has been variable. In one trial in a high rainfall site it has yielded well (table 11). However in another site (tables 12 and 19) with more limiting conditions, it shows low vigour with low yields. The rootstock has no nematode resistance and does not tolerate drought. Quite a degree of interest in it as a low vigour rootstock. Needs to be evaluated in a broader range of sites.

Observe quarantine protocols to prevent the spread of pests and diseases.

Fercal was developed in France to suit soils high in lime. It is a complex hybrid which has *V. vinifera* in its parentage. It has only been tested in one site in Greater Victoria where the soil was a clay loam and the site relatively cool (table 18). In that site it yielded less than ungrafted vines (the highest yielding treatment) and similar to a number of other rootstocks. Needs to be evaluated in a broader range of sites.

125 AA is a *V. berlandieri x V. riparia* hybrid and it has been tested at one site (table 11). Its performance was similar to other rootstocks with no particular advantage or disadvantage. Needs to be evaluated in a broader range of sites.

Rootstocks of Limited Potential

Rupestris du Lot (also known as Rupestris St George) is a *V. rupestris* selection which has been grown in Australia since the 1900's. It has been evaluated in several trials and has some limitations, ie. it has no nematode tolerance, the roots form nodosities with some clones of phylloxera, yields are not as high as other rootstocks, and juices tend to be high in potassium resulting in high juice pH. Not recommended.

1202 Couderc is a *V. vinifera x V. rupestris* hybrid. It has been grown in Australia since the early 1900's. It has little nematode resistance and is reputed to lack resistance to phylloxera overseas. It appears to have sufficient resistance to some clones of phylloxera in Australia, but given the experience of the breakdown of resistance of ARG No1 in California to new clones of phylloxera it should not be planted. It also takes up more salt than other rootstocks. Not recommended.

ARG No1 is a similar hybrid to 1202 and has been grown in Australia for a similar period of time. It has little nematode resistance and although it performed well up to the 1970's, recent trials show it is susceptible to phylloxera. It takes up more salt than other rootstocks. Not recommended.

1613 Couderc was imported into Australia in the 1960's for it's nematode resistance. It has not performed well in any trials in Greater Victoria, lacking vigour and appearing unsuited to the heavier soils. Not recommended.

Harvesting rootstock trial plots.

Harmony is another rootstock imported for its nematode resistance. It has performed reasonably well in hot, irrigated areas with sandy soils, although high potassium uptake and susceptibility to some nematode species limit its use. In Greater Victoria it has performed only moderately well and other rootstocks are better. Not recommended.

Freedom is a similar hybrid to Harmony but with more vigour. It has yielded well in one trial in central Victoria but had very high vigour and high juice potassium and pH, and does not exclude salt as well as other rootstocks. Not recommended at this stage – could be evaluated further.

K51-32 was imported as nematode resistant rootstock with less vigour than Ramsey. Performed moderately well in hot, irrigated areas with sandy soils, but its performance has been variable in Greater Victoria. It does not perform when subjected to water stress in shallow soils, and has a higher salt uptake than other stocks. Not recommended.

K51-40 a similar hybrid to K51-32, but with a little more vigour. Similar characteristics to K51-32. Not recommended

Variation in expression of lime induced chlorosis between rootstocks. L. Schwarzmann, R. Dog Ridge

Rootstock Selection According to Soil Characteristics

The starting point in rootstock selection is to refer back to the section on 'Characteristics of common hybrid rootstocks' (p. 5). Having a basic understanding of the site characteristics will indicate the type of rootstock you may need. For example:

- Ample soil moisture, cool climate, deep soils ➔ *V. riparia x V. rupestris* (eg. 3309, 3306, 101-14, Schwarzmann)
- Reasonable soil moisture, cool climate, medium depth soils ➔ *V. berlandieri x V. riparia* (eg. SO4, 5BB Kober, 5C Teleki, 420A)
- Limited soil moisture, warm to hot climate, shallow soils ➔ *V. berlandieri x V. rupestris* (eg. 1103 Paulsen, 99 Richter, 110 Richter, 140 Ruggeri)

Since a major consideration in selecting rootstocks is their suitability to different soil characteristics a further breakdown of the suitability of rootstocks for certain situations is provided in the table below.

Soil Depth	Soil water status	Acid or neutral soil	Calcareous soil
Shallow (<20cm)eg. shallow duplex (Kurosols, Sodosols, Chromosols)	Dry	110 Richter, 140 Ruggeri	110 Richter, 140 Ruggeri
	Irrigated	110 Richter, 140 Ruggeri, 99 Richter, 1103 Paulsen, 5BB Kober, 5C Teleki, SO4, Teleki 'C', Ramsey	110 Richter, 140 Ruggeri, 1103 Paulsen
Medium (20-75cm)eg. gradational earths, deeper duplex (Ferrosols Calcarosols, Dermosols, Kandosols)	Dry	110 Richter, 140 Ruggeri, 1103 Paulsen, 99 Richter, Teleki 'C', 5BB Kober	110 Richter, 140 Ruggeri, 1103 Paulsen
	Irrigated	110 Richter, 140 Ruggeri, 1103 Paulsen, 99 Richter, Teleki 'C', 5BB Kober, 101-14, Schwarzmann, 3309 Couderc, 3306 Couderc, Riparia Gloire (not in sand)	110 Richter, 140 Ruggeri, 1103 Paulsen, 5C Teleki, 5BB Kober, Fercal (not fully tested in Australia)
Deep (>75cm)eg. sands, loams, clays (Calcarosols, Dermosols, Kandosols, Ferrosols)	Dry	110 Richter, 1103 Paulsen, 99 Richter, 5BB Kober	110 Richter, 1103 Paulsen
	Irrigated	110 Richter, 1103 Paulsen, Schwarzmann, 3309 Couderc, 5C Teleki, 101-14, Riparia Gloire (not in sand)	110 Richter, 1103 Paulsen, Fercal (not fully tested in Australia)

The rootstocks associated with the primary soil characteristics (soil depth, water availability and pH) have been summarised in the table. Locate the rootstocks in the section most closely associated with the conditions in which the vines are to be planted. Then consider the additional characteristics below to further clarify your choice. Also check the suitability of selected rootstocks by reading the individual rootstock descriptions in the section on 'Characteristics of commonly used rootstocks'.

Some additional characteristics to consider
(based on local and international experience)

Phylloxera resistance – All rootstocks in the table are regarded as having adequate resistance.

Nematode resistance – Most rootstocks have adequate resistance except Riparia Gloire, 3309 Couderc and possibly Fercal.

Waterlogging – No rootstock is specifically adapted to waterlogged soils and ungrafted vines generally perform better. Avoid 99 Richter, 5BB Kober, SO4, 420A, 101-14, 140 Ruggeri and Ramsey.

Vigour – Remember that growth is largely controlled by water availability (from irrigation, rainfall or high soil water availability) and vigour will decrease under limited water. Moderate to high vigour rootstocks include 140 Ruggeri, SO4, 5BB Kober, Ramsey and Teleki C. Consistently medium vigour rootstocks are 5C Teleki, 1103 Paulsen and 3309 Couderc. Rootstocks with moderate to low vigour are Schwarzmann, 101-14, 420A, 110 Richter and Riparia Gloire.

Soil salinity – Of the rootstocks in the table, 140 Ruggeri and 1103 Paulsen are considered the best. Others to consider are 101-14, Ramsey, Schwarzmann, 110 Richter, 99 Richter and 5BB Kober.

Soil acidity – If minimal liming is used, consider 140 Ruggeri, 1103 Paulsen, 110 Richter and 99 Richter. Avoid Schwarzmann, 101-14, SO4, Ramsey, 5C Teleki, 5BB Kober and 3309 Couderc.

Low potassium in juice and wine – Potentially a concern with red grapes where skin content during fermentation releases potassium from the skins into the wine. Moderate amounts of potassium are found with Schwarzmann, 101-14, 140 Ruggeri, Ramsey, 99 Richter and 3309 Couderc. Lowest potassium in wine come from the rootstocks 110 Richter, 5C Teleki, 5BB Kober, 1103 Paulsen and SO4. The rootstocks with high potassium levels are not suggested for use in Greater Victoria (eg. K51-40, K51-32, Freedom, Harmony, Rupestris du Lot, and Dog Ridge).

Left:
Yellowing of leaves and reduced shoot growth due to the early stages of a phylloxera infestation in ungrafted vines.

Top:
Vines grafted to 99 Richter infected with Phytophthora.

Above:
Leaf burn from salting in ungrafted Shiraz

Grapevine Clones

A well established, even vineyard using clonal planting material.

Background

Within any planting of a particular variety there is variation in characteristics of the vines. This may be due to variations in soil characteristics, for example, across the planting, but there may also be some inherent differences between vines. These inherent differences are due to some change in the genetic make-up of the vines, often from a mutation. Clones may also be produced by meristem tip culture or heat treatment, where this is often related to removal of viruses.

If these mutations occur in the dividing tissue, then the shoot that grows away may be changed and propagating cuttings from that shoot will carry that genetic change through into mature vines. For example, occasionally on a white grape variety one shoot can have red coloured grapes on it. Propagating that shoot will then produce vines with all of its fruit red.

These mutations occur at a low rate, so the best chance of obtaining mutations is in older vineyards where vines have been exposed to natural radiation for a long period of time. The nursery industry relies on vegetative propagation of grapevines thus different characteristics can be readily transferred to the industry.

Some mutations are very obvious, such as the reversion of some shoots on Pinot meunier vines to Pinot noir. Other mutations are far less obvious, such as changes in berry size, fruitfulness, and ability to set fruit. These generally require some process of measuring and recording over some years to ensure it is a genetic change and not a transient environmental difference.

In Australia, the early focus with clonal selection and evaluation was on freedom from virus and improving yield. Under the relatively low input production systems in the 1950's, yields were considered to be too low to sustain profitability with the grape prices being paid. By increasing yield and maintaining quality there were better returns to growers. However, since that time, production systems have embraced higher inputs as a means of improving productivity. The combination of improved clones and increased inputs has in some cases generated vines that are out of balance and fruit quality has suffered as a consequence.

The combination of improved clones and increased inputs has in some cases generated vines that are out of balance and fruit quality has suffered as a consequence.

Whilst there is a focus on maintaining virus freedom, improving yield is not always desirable. The industry is now focusing more on quality attributes. This may now involve earlier ripening for some situations, less compact bunches to reduce bunch disease problems, different flavour/aroma profiles, lower pH, higher tartaric to malic acid ratios, smaller berries and improved colour and phenolics. These quality attributes have not been well researched to date.

Sources of Clones

Anything propagated originally from a single bud is eligible to be called a clone. As each vine arises from a single bud then effectively we have one original source vine or 'mother' vine to work from. Whilst the original source vine may be located in a vineyard it is common for vine improvement schemes to establish source vines within a confined area from which they can propagate and distribute planting material.

All clones are given a code name, often relating back to the original source vine. In Australia many clones are listed in the 'National Register of Grapevine Varieties and Clones' (deLaine and

Nicholas 2000) produced by the Australian Vine Improvement Association. Some attempt to register clones imported into Australia has been made through the Department of Agriculture, Fisheries and Forestry Australia. However information on privately imported clones is not disclosed publicly. Also there have been a multitude of clones selected within Australia and generally only the common or rigorously tested ones make it into the Register.

The Register explains the codes used on the clones, and where possible reference to overseas clonal coding is used, eg. to the FPMS (Foundation Plant Material Service, eg. at Davis, California) code number. This enables growers to interpret some of the information published overseas.

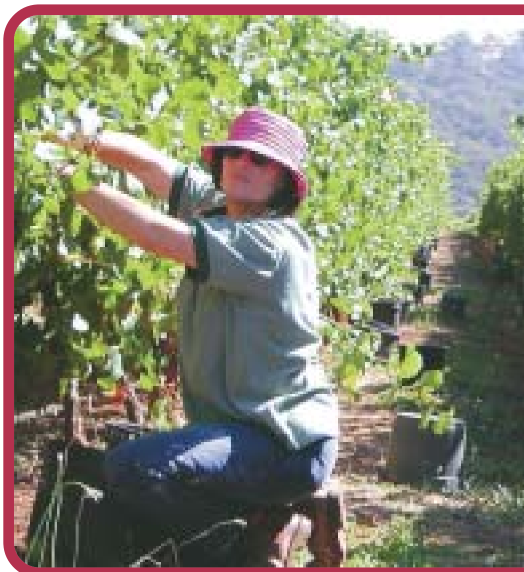
Clonal Evaluation

The quality of information available on clonal evaluation varies considerably. Clones should be compared under the same conditions to obtain reliable and adequate evaluation. In any vineyard block there are variations in soil characteristics across the area, many may not be obvious on the surface. To adequately cover this variation, the testing must be **replicated** and **treatments allocated randomly** across the block. This entails some degree of rigour and expense but relative differences between clones under these situations are meaningful.

In some reports, perhaps comparing adjacent rows of different clones or even clones grown in different blocks, there may be variations in site contributing to the reported differences between clones. Thus these sorts of results may not reflect a 'true' clonal difference, unless they agree with some other 'reference' trial that has been adequately designed. If no other reference trial is available then further information is required before accepting the purported characteristics of such clones.

Clonal trials are often inadequately designed, mainly due to less than desirable numbers of replications. This is commonly due to insufficient quantities of planting material being available and the greater resources required to collect the data. Based on typical vine-to-vine variability in vineyards for yield (Coefficient of Variation 25-45%), to detect a 25% difference in yield between two treatments, a minimum of around 15 replications would be required.

In Victoria, clonal evaluation has been under-resourced and trial work has largely been conducted with those growers who have had an interest in determining suitable clones for their site. Systematic evaluation has not had industry support, and consequently it is difficult to recommend clones for specific situations. A common question, for example, is 'what is the best clone for the Yarra Valley?' Unfortunately the information available is not adequate to address those sorts of questions.



Harvesting trial plots.

Clones should be compared under the same conditions to obtain reliable and adequate evaluation.

Viruses Important in Australia

The viral content across clones varies. Many viruses were mixed and spread during the early stages of grafting with rootstocks that were used to combat phylloxera. Some rootstocks are symptomless carriers of viruses and problems were not recognised until certain varieties were grafted onto them. Back in the 1950's viruses, particularly leafroll virus, were present in many vineyards and impacting on yield. With the advent of vine improvement schemes most recent plantings are free of detrimental virus. The virus information on clones is held by state vine improvement associations and is not included in the National Register. A good account of grapevine viruses in Australia is provided by Krake et al. 1999.

Clones should be free of the following viruses:

Leafroll (closteroviruses) – nine stains have been detected so far. GLRaV-1 and GLRaV-3 are the most common and can produce yield reductions of up to 50%. Leafroll can also affect grape quality by reducing the sugar and anthocyanin content. GLRaV-2 may cause graft incompatibility. GLRaV-3 (and probably GLRaV-1) can be spread by mealybugs and vine scale.

Rugose wood complex (vitiviruses) – at least four different types of disease can be distinguished by biological indexing: Rupestris stem pitting, Kober stem grooving, corky bark and LN33 stem grooving. These syndromes are difficult to distinguish in the field and mainly cause problems with grafted vines. Symptoms

Leafroll virus symptoms

include swelling above the graft, and wood with pits or grooves (seen after bark is removed). Budburst may be delayed. Vines may decline and even die – this varies with the stock/scion/virus interaction. Water stress and the combination of rugose wood and leafroll viruses increase the problems. Kober stem grooving and corky bark can be spread by mealybugs.

Fleck – no field symptoms of fleck virus are seen on *V. vinifera* and most rootstocks. The combination of fleck and leafroll may reduce graft take.

Fanleaf (nepovirus) – symptoms include fan-shaped leaves and distorted canes or yellow mosaic symptoms, smaller bunches, shot berries and greatly reduced yield. Fanleaf does occur in Victoria, but it is not as important here as in Europe, because the nematode vector *Xiphinema index* is only present in the Rutherglen region.

Clonal Results

The results from clonal trials in Greater Victoria are limited. A number of extra clonal trials are established but have not been fully assessed as yet. Comments are generally restricted to those clones where DPI has information, and it may be that there are better clones available. Information about other clones is referenced where available.

In selecting clones growers need to decide what attributes they are seeking. In the past, much of the trial work has focused on yield because prior to the 1970's low yield was a significant factor in the profitability and competitiveness of the industry. However, while attempts to lift yield based on clonal selection were underway, improvements in other cultural operations, eg. irrigation, nutrition, trellising, and soil management, also contributed to improved yields. The quality components of clones with regard to colour, flavour and aroma were largely ignored. Whilst some work has been undertaken, the profiling of grape and wine quality of clones is well behind our international competitors.

Cabernet Sauvignon (tables 22 and 23)

More detailed information on clonal assessment of Cabernet sauvignon in South Australia is available in Cirami et al. 1993. Information from trials in Victoria is presented here.

- FVG9V3 – sourced from Foundation Plant Material Service, Davis, California. Has consistently yielded well in several trials. Has more fruit driven characters and less herbaceous character in the wine than some other clones.

- SA 125 – a selection from the Barossa Valley which has yielded reasonably well in many trials. It is a selection that has more herbaceous character in the wine than other clones. This clone also contains a strain of leafroll virus (Habili and Rowhani 2002). The leafroll on its own appears to have little impact on performance. However in combination with other viruses, either through top-working or grafted to rootstocks, this clone may not perform as well.

- SA 126 – selected at the same time as SA 125 from the Barossa Valley. This clone also yields reasonably well and has a wine character more like FVG9V3 (less herbaceous than SA 125). It does not usually have any leafroll virus.

- Several clones have yielded reasonably well in a trial at Irymple (Whiting and Hardie 1980). Apart from FVG9V3, the clones SA125, SA126, R3V19E (a selection from Coonawarra), and R2V1W (a selection from Great Western), yielded well. Several clones from the Institut National de la Recherche Agronomique (INRA) (BX5186 and BX5325) yielded less well. BX5186 also had low sugar concentrations. One INRA selection (BX5197) yielded poorly with low bunch number per vine and fewer berries per bunch.

Chardonnay (tables 24 and 25)

Cirami and Ewart (1995) summarised clonal evaluation work in South Australia and presented some comments on wines made from clones. In Victoria evaluation has been restricted to yield and maturity performance and some results differ to those described by Cirami and Ewart (1995).

- FVI10V1, V3, and V5 – These clones were compared at Drumborg. FVI10V5 yielded significantly higher than V3 and V1, but whilst less than G9V5 and G9V7, was not significantly less. FVI10V5 yielded higher than V3 and V1 due to more berries per bunch. There were no significant differences with bunch number per vine and berry weight. FVI10V5 ripened later than V3and V1 with consequent higher acid and lower pH.

- FVG9V5 and V7 – High yield due to heavier bunches from high berry numbers per bunch. A later ripening clone (perhaps due to the higher yield). The compact bunch makes it more susceptible to bunch rots in a cool climate.

- Penfold 58 – data limited to some buffer vines in a trial at Drumborg and an unreplicated planting at Nagambie. Has lower yield mainly due to fewer berries per bunch. A commonly used clone in cooler areas.

- OFF1V3 – sourced from the Old Foundation source block at FPMS Davis. Very low yield.

Dolcetto (tables 26 and 27)

Clones of Dolcetto were selected from old plantings at Bests and Seppelts (now Southcorp) at Great Western. There were no significant differences in any of the measurements between the Bests clones. With the Seppelts selections, there were some differences between clones for yield, bunch number per vine, sugar and acid, the most striking difference being the much lower sugar of SGW 0539.

Traminer (table 28)

Only tested at one site near Mansfield, in a cool climate.

- No significant differences between clones with sugar concentration, titratable acid, pH and berry weight.

- No significant difference in yield between most clones. FVH8V9 had a low yield due to fewer bunches per vine. Traminer 456 had the lowest bunch weight due to fewer berries per bunch.

Merlot (table 29)

Only tested at one site near Dromana on the Mornington Peninsula.

- FVD3V14 – highest yield in this trial but not significantly better than FVD3V5, FVD3V7 and RVC13. Used widely across the industry because setting in Merlot can be poor at times hence the need to maximise yield potential. Has bigger berries and higher pH than FVD3V5 and RVC13.

- FVD3V5 and V7 – The only significant differences between these is that FVD3V7 had a higher sugar level and lower acidity at harvest than FVD3V5.

- RVC13 – is of interest as it has a significantly lower berry weight and significantly higher sugar level than all other clones in the trial. Despite having the highest sugar level it has a significantly lower pH than FVD3V14.

- The RBK1, 2 and 3 clones displayed symptoms of leafroll in each season, with symptoms particularly strong in RBK2, which could explain its poor performance (low yield, low berry number per bunch, low sugar level).

Pinot Noir (tables 30, 31 and 32)

Three trials were planted in two different situations, one a high rainfall, deep fertile soil, cool climate region and the other a low rainfall, shallow duplex soil in a warm climate. Some inconsistencies in relative performance between clones at the different sites but data was collected in different seasons and different management practices across the trials may have influenced the results. Meunier, a periclinal mutant of Pinot noir (Boss and Thomas 2002), has been included in 2 trials for comparison. Cirami and Ewart (1995) also report on the performance of Pinot noir clones from several trials at Nuriootpa and Coonawarra.

Block 'D' at FPMS, Davis, where the original source vine of Merlot FVD3V14 (Foundation Vineyard, Block 'D' Row 3, Vine 14) is located.

- MV6 – is a selection from an old vineyard in the Hunter Valley taken by McWilliams. It is generally considered a low yielding clone, and that is the case in these trials. It has a lower bunch weight than most other clones, primarily due to fewer berries per bunch. The berry weight of MV6 is not different to most other clones. In one trial (table 30) MV6 ripened much earlier than the other clones but in the other trials it did not. Wines made from the clone also have a distinct flavour profile, compared to 4 other clones, and were described as having good 'Pinot' fruit character, with a soft, rich mid palate (Noon et al. 1989).

- FVD5V12 – this is a distinctive clone because of its upright growth. Other clones have pendulous or semi pendulous shoot growth. The clone has yielded well at Great Western but not so at Drumborg. At Great Western the higher yield is due largely to more berries per bunch than other clones and not bigger berries. FVD5V12 had lower sugar at harvest than most other clones. Wine tasting comments described the clone as having berry fruit characters, but lacked richness and was a bit thin.

- FVD2V5 – this selection originated from Wadenswil, Switzerland, where it had the designation B111. Its yield has been variable in the 3 trials from high to moderate. The wine tasting comments described the clone as having berry fruit characters, but lacked richness and were a bit thin.

Pinot noir clone B110/16 (FVD2V6)

- Gm18 – this clone originates from Geisenheim, Germany. It has had high yields in 2 trials due to a combination of high bunch numbers per vine and relatively high bunch weight (due to more berries per bunch).

- Mariafeld – this clone also originates from Switzerland. It is high yielding which is primarily associated with a larger bunch weight due to heavier berries (significantly heavier than all other clones). The pH of the juice is significantly lower than all other clones. This is associated with high titratable acid but not necessarily the lowest sugar level.

Riesling (table 33)

Not a replicated trial so definitive conclusions cannot be made. All clones tested seem to have good yields. Differences in yield are related more to bunch weight than bunch number per vine. Further information has been presented in Ewart and Sitters 1988, and McCarthy 1988.

Sauvignon Blanc (table 34)

Only one year of results, but FVH5V10 clearly out-yielded the SA clones. The sugar level was less than the other clones (due to the higher yield) but ripened adequately for the region. See Ewart et al. 1993 for more information on Sauvignon blanc clones.

Shiraz (tables 35, 36 and 37)

One large trial at Mildura compared commonly used selections from New South Wales and South Australia with selections of Shiraz from Bests Wines vineyards at Great Western and Tresco. Many of the Bests clones yielded as well as those from SA and NSW. At Ararat and Great Western, 2 trials compared NSW and SA clones along with several others. Cirami and Ewart 1995 reported on four trials but different combinations of clones to those in Victoria make comparisons difficult.

- CSIRO R7V1 – has been the highest yielding clone in 2 trials. It does not differ much to other clones in other respects, ie berry size is not different to most other clones but it had lower sugar at harvest than several other clones.

- NSW clones – in the Great Western trial there were no significant differences in yield between NSW 10, 15 and 23. In the Mildura and Ararat trials, NSW15 yielded significantly higher than NSW10, but not higher than NSW23 and 19 (the latter at Mildura only). With other attributes NSW10 had a lower berry weight than 15 and 23 at Great Western, NSW 15 had lower sugar at harvest than NSW 10 at Ararat, and NSW23 had a higher pH than NSW 10 and 15 at Mildura. Overall there are no consistent and clear differences between the NSW clones.

- SA clones – several 'SA' clones were compared in the Mildura trial. SA1654 had a higher yield than SA1127, but not higher than SA712. SA712 had heavier berries than SA1127 and there were no significant differences with aspects of maturity. In the Ararat trial, SA1654 was compared to a number of other clones where it yielded significantly better than NSW10 and Tahbilk R7V3E, and it had significantly heavier berries than CW73-16, NSW23, 'Caracosa', NSW10 and Tahbilk R7V3E.

- BVRC clones – BVRC 12 and 30 were compared in 2 trials. There were no significant differences between the 2 clones for any of the measures.

- Tahbilk clones (table 36)– there is some interest in 'heritage' clones, ie. selections made from old vines. Tahbilk R7V3E was lower yielding than the other 2 clones due to fewer bunches and lower bunch weights, with smaller berries. Tahbilk R2E had a lower sugar at harvest than the other 2 clones, and R6W had a higher acid level at harvest.

- Other clones – ESA 3021 yielded more than several clones at Ararat, CW73-16 yielded as well most other clones, but its berry weight was not as high as some other clones. 'Caracosa' came from the old variety collection at Rutherglen and was only out-yielded by CSIRO R7V1 and ESA 3021.

Mechanical harvesting of wine grapes.

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Tables of Rootstock and Clonal Results from Greater Victoria

Department of Primary Industries Trials

The trials conducted in Greater Victoria are set up in accordance with standard statistical designs. In some cases demonstration plots were established. In the trials, treatments were planted in plot sizes ranging from 1 to 4 vines per plot. Treatments are randomised across the site and replicated in blocks. The trials were maintained by participating growers.

Harvesting of trials is conducted on the one day to fit with the growers' harvesting logistics. The harvest date may not always be the optimum maturity but the fruit is usually blended with other fruit being harvested at the time. Some treatments that may be lower in sugar at harvest, may well reach a desired sugar level with further time on the vine.

The usual procedure is for samples of 50 berries to be collected from individual treatment vines. Then each vine is picked, counting the bunches removed and weighing the crop. Bunch weight is calculated from the yield and bunch number per vine. The berry samples are weighed to determine average berry weight, then crushed and the juice tested for sugar level by refractometer, pH by electrode and titratable acidity by auto-titrator to end-point pH 8.2 with 0.1M NaOH. Juice samples may sometimes be frozen for analysis at a later stage. Berry number per bunch is calculated from mean bunch weight and mean berry weight.

To Interpret the Tables.

An LSD (Least Significant Difference) is supplied to compare means. A standard probability level of 5% (or $P<0.05$) is used. This crudely relates to a chance of 1 in 20 that the significant difference may be incorrect. This is an acceptable situation for grape vine comparisons.

If two means differ by more than the LSD, then we can say they are significantly different. If the difference between the means is equal to or less than the LSD then we say there is no significant difference between the treatments.

For example , in table 1, for yield where the LSD is 0.4, 1202 (4.4 kg/vine) is significantly different to Ramsey (3.9 kg/vine), but 5BB Kober (3.5 kg/vine) is not significantly different to Ramsey (3.9 kg/vine).

NS = not significant, ie. there are no significant differences between treatments at a probability of 5% or less.

NA = an LSD is not available.

Provisional Rootstock Trial Results

Table 1

Brown Muscat ex CSIRO, Glenrowan, duplex soil, replant, phylloxera, mean 5 years, dryland

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
1202	4.4	44.6	83.9	55.3	1.56	31.0	4.41	3.80
Ramsey	3.9	41.6	84.7	55.1	1.57	29.7	4.42	3.75
5BB Kober	3.5	38.4	77.4	53.0	1.52	30.3	4.34	3.84
110 Richter	2.7	32.2	71.7	49.9	1.45	29.9	4.54	3.80
5A Teleki (5BB Kober)	2.7	31.2	68.9	45.6	1.49	31.5	4.13	3.87
Harmony	2.6	29.1	72.8	48.2	1.49	31.4	4.39	3.88
Ungrafted	2.4	28.1	72.3	50.9	1.38	30.4	4.39	3.81
Schwarzmann	2.2	28.1	65.1	46.0	1.41	31.1	4.34	3.87
K51-32	2.0	26.9	64.4	48.9	1.37	31.4	4.30	3.92
5C Teleki	1.9	23.3	63.7	46.5	1.39	30.2	4.16	3.85
LSD (5%)	0.4	4.1	5.8	4.7	0.07	0.8	0.19	0.05

Table 2

Brown Muscat ex CSIRO, Glenrowan, sandy duplex soil, virgin site, mean 5 years

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
Ramsey	6.3	70.7	121.9	68.6	1.71	25.1	4.50	3.72
1202	6.1	63.5	120.6	64.7	1.76	26.2	4.76	3.76
Harmony	4.7	43.7	121.4	64.1	1.68	27.2	4.19	3.84
Rupestris du Lot	4.5	55.1	106.6	60.9	1.65	26.7	4.57	3.84
5C Teleki	4.4	57.3	100.9	63.8	1.58	25.9	4.44	3.76
110 Richter	4.3	49.9	109.1	60.7	1.67	26.3	4.40	3.78
Ungrafted	4.2	46.1	110.7	60.0	1.73	26.6	4.14	3.76
420 A	4.2	47.9	109.0	64.4	1.62	25.9	4.48	3.70
Schwarzmann	3.5	39.3	96.6	56.7	1.60	27.2	4.38	3.88
LSD (5%)	0.8	8.3	12.8	NS	0.08	0.6	0.20	0.05

Table 3

Brown Muscat ex CSIRO, Milawa, duplex soil, replant, phylloxera, mean 5 years

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
5A Teleki (5BB Kober)	8.8	93.0	95.7	54.5	1.77	26.0	5.57	3.56
5BB Kober	8.6	87.4	101.2	54.4	1.85	25.5	5.53	3.56
5C Teleki	8.3	81.0	102.0	55.3	1.84	25.3	5.54	3.56
Ramsey	8.0	91.6	91.8	50.9	1.80	24.9	5.61	3.53
Schwarzmann	8.0	85.4	95.4	53.8	1.79	26.2	5.30	3.64
Harmony	7.2	83.4	95.5	52.8	1.77	25.7	5.34	3.60
1202	7.1	83.6	94.5	52.7	1.73	25.9	5.87	3.55
Rupestris du Lot	7.1	75.4	95.3	56.8	1.74	25.2	5.86	3.57
110 Richter	6.5	77.6	92.5	54.2	1.78	25.3	5.39	3.54
420 A	6.2	76.0	83.6	47.0	1.79	25.6	5.36	3.52
K51-32	5.6	67.7	92.1	54.0	1.70	26.0	5.23	3.58
Ungrafted	4.3	52.2	82.4	52.7	1.62	26.4	5.29	3.55
LSD (5%)	0.8	7.9	8.4	NS	0.05	0.5	0.20	0.04

Table 4

Cabernet Sauvignon FVG9V3, Wahgunyah, replant sandy soil, mean 5 years, nematodes

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
5C Teleki	10.6	139.7	75.0	62.5	1.19	22.4	6.1	3.50
Ramsey	9.4	123.3	73.7	64.9	1.14	22.6	6.0	3.47
5BB Kober	8.8	130.4	64.6	58.3	1.10	22.7	6.3	3.53
110 Richter	8.8	123.0	66.3	58.0	1.14	22.9	6.3	3.46
Harmony	8.7	120.4	68.3	62.3	1.08	23.1	5.9	3.47
Schwarzmann	7.3	117.6	57.9	58.6	1.00	23.1	5.9	3.49
Rupestris du Lot	6.6	109.9	57.1	58.0	0.99	23.1	6.1	3.45
ARG No 1	5.5	97.1	53.2	55.8	0.95	22.3	6.0	3.45
Ungrafted	5.2	91.9	50.6	51.9	0.96	22.7	6.1	3.48
LSD (5%)	1.2	12.9	6.0	4.9	0.04	0.4	NS	0.05

Table 5

Cabernet Sauvignon FVG9V3, Mornington Peninsula, sandy soil, mean 4 years

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
K51-40	4.2	55.9	76.0	64.0	1.26	22.3	7.32	3.44
5C Teleki	4.1	57.9	72.4	66.7	1.14	22.3	7.11	3.49
Schwarzmann	4.0	48.9	85.6	78.3	1.15	22.5	6.83	3.52
K51-32	3.9	50.6	79.7	69.6	1.20	22.7	7.01	3.51
99 Richter	3.8	55.4	71.8	69.7	1.10	22.5	7.08	3.46
Ramsey	3.8	53.6	72.3	63.0	1.21	22.3	7.21	3.45
5BB Kober	3.7	51.6	75.4	66.0	1.21	22.5	7.30	3.47
Ungrafted	3.5	52.9	70.1	65.9	1.12	22.1	7.04	3.46
LSD (5%)	NS	NS	7.5	7.4	0.04	0.3	NS	0.05

Table 6

Cabernet Sauvignon FVG9V3, Nagambie, Duplex Soil, mean 4 years (Phylloxera)

Rootstock	Yield kg/vine	Berry wt g	Sugar °Brix	Titratable acid g/l	pH	Potassium mg/l	Pruning wt kg/vine
Freedom	9.9	1.23	22.9	7.7	3.50	1500	1.36
99 Richter	9.9	1.20	22.9	7.7	3.49	1571	1.69
140 Ruggeri	9.7	1.23	23.4	7.7	3.49	1541	1.52
5BB Kober	9.7	1.27	22.8	7.8	3.49	1455	1.53
5C Teleki	9.6	1.26	22.8	7.6	3.46	1445	1.30
Schwarzmann	9.6	1.20	22.9	7.3	3.49	1498	1.29
Ramsey	9.2	1.24	22.5	7.5	3.48	1456	1.23
K51-32	8.5	1.23	23.2	7.3	3.52	1643	1.28
Rupestris du Lot	8.1	1.20	23.2	7.4	3.53	1652	1.34
K51-40	8.0	1.21	23.0	7.3	3.48	1445	0.99
110 Richter	7.8	1.20	23.0	7.3	3.45	1367	0.84
ARG No1	5.3	1.08	22.9	7.2	3.41	1322	0.51
Ungrafted	2.4	0.89	23.5	6.7	3.49	1381	0.17
LSD (5%)	0.5	0.05	0.4	0.3	0.03	145	0.14
Years of data	4	4	4	4	4	2	2

Table 7

Cabernet Sauvignon FVG9V3, Yarra Valley, sandy duplex soil, mean 4 years

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
Ramsey	3.8	48.2	73.7	82.0	0.92	21.6	6.08	3.44
1202	3.3	47.6	65.1	74.6	0.85	22.1	5.68	3.57
5A Teleki	3.0	40.4	69.1	80.8	0.85	22.0	5.90	3.57
Harmony	2.8	41.8	63.7	76.1	0.83	22.0	5.82	3.60
K51-32	2.7	39.0	63.6	72.3	0.90	22.1	5.97	3.55
ARG No1	2.7	44.6	56.6	66.8	0.84	21.8	5.76	3.54
Schwarzmann	2.6	38.1	65.3	80.5	0.80	22.2	5.83	3.60
Rupestris du Lot	2.3	37.4	59.5	75.5	0.78	21.7	5.68	3.60
Ungrafted	1.8	30.8	52.3	67.6	0.77	21.8	5.53	3.58
LSD (5%)	0.5	5.2	8.4	9.6	0.06	0.4	0.27	0.07

Table 8

Cabernet Sauvignon FVG9V3, Myrrhee, 2 years

	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
Teleki C	8.0	67.5	118.4	103.9	1.18	23.5	5.65	3.51
SO4	7.8	66.9	116.6	96.6	1.24	23.2	5.67	3.47
140 Ruggeri	7.5	63.9	114.5	100.6	1.17	23.5	5.35	3.53
1103 Paulsen	6.9	66.0	102.2	100.5	1.06	22.9	5.49	3.50
Schwarzmann	6.5	58.7	110.8	108.7	1.06	22.1	5.45	3.47
LSD (5%)	0.8	NS	8.5	8.0	0.07	0.3	NS	0.03

Table 9

Chardonnay FVG9V7, Great Western, mean 5 years

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
1613	3.9	31.3	124.7	107.3	1.11	21.7	7.8	3.41
1202	3.8	30.0	118.0	106.7	1.10	21.7	8.0	3.41
3309	3.7	29.3	121.3	107.3	1.11	21.3	7.9	3.39
ARG No1	3.6	29.7	115.3	104.7	1.09	21.7	7.5	3.40
5A Teleki (5BB Kober)	3.4	28.3	118.7	106.0	1.09	21.9	7.5	3.41
5C Teleki	3.4	28.3	123.0	106.7	1.14	22.2	7.5	3.42
110 Richter	3.4	28.7	113.3	101.3	1.11	21.4	7.8	3.39
Ramsey	3.3	30.1	119.7	108.0	1.10	21.6	7.6	3.41
140 Ruggeri	3.2	29.0	114.7	101.3	1.10	21.9	7.9	3.42
Harmony	3.2	28.3	113.0	105.7	1.06	21.7	7.9	3.44
Ungrafted	3.2	28.3	107.7	100.0	1.07	20.9	7.8	3.39
Schwarzmann	3.1	29.0	113.3	102.0	1.10	22.0	7.6	3.44
K51-32	3.1	28.7	112.0	98.3	1.12	22.3	7.7	3.44
Rupestris du Lot	3.1	28.0	112.7	103.0	1.09	21.8	7.9	3.46
LSD (5%)	NA	NA	NA	NA	NA	NA	NA	NA
Number of years	5	3	3	3	4	4	4	4

Table 10

Chardonnay FV I10V1, Wahgunyah, sandy soil, replant, mean 6 years, phylloxera and nematodes

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
5C Teleki	11.1	142.0	75.8	59.2	1.34	23.1	7.5	3.50
5A Teleki (5BB Kober)	10.9	135.4	77.7	59.9	1.35	23.1	7.2	3.49
Schwarzmann	9.8	124.7	77.4	61.4	1.31	23.3	7.1	3.56
Harmony	9.7	136.7	69.1	52.8	1.33	23.8	7.4	3.52
5BB Kober	9.3	120.3	75.8	60.9	1.30	23.2	7.0	3.53
ARG No1	9.1	114.8	77.6	66.3	1.22	23.1	6.5	3.48
110 Richter	8.5	106.9	76.1	65.5	1.24	22.9	6.6	3.50
Rupestris du Lot	7.8	113.2	66.3	57.1	1.24	23.6	6.6	3.56
Ungrafted	5.8	78.6	72.8	66.7	1.15	22.4	6.8	3.54
LSD (5%)	1.0	10.5	5.5	4.6	0.05	0.4	0.3	0.04

Table 11

Chardonnay FVI10V5, Whitlands, 3 years, Krasnozem soil

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
Ramsey	8.3	64.8	131.2	106.3	1.25	19.9	6.64	3.31
420 A	8.1	63.2	130.3	107.7	1.22	19.5	6.48	3.32
Riparia Gloire	7.5	57.5	135.2	108.9	1.24	20.6	6.14	3.37
110 Richter	7.3	53.9	137.9	107.4	1.29	20.0	6.14	3.31
125 AA	7.1	55.7	134.7	110.9	1.22	20.0	6.36	3.38
140 Ruggeri	7.0	59.5	121.5	102.4	1.20	20.4	6.48	3.40
101-14	6.8	58.6	117.5	102.5	1.15	20.8	5.88	3.39
5C Teleki	6.7	56.4	124.0	103.8	1.21	20.2	6.39	3.39
1103 Paulsen	6.6	60.7	113.2	96.2	1.19	20.1	6.44	3.38
LSD (5%)	0.9	NS	8.8	7.7	0.05	0.5	0.35	0.04

Table 12

Chardonnay FVI10V1, Porepunkah, mean 2 years

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
5BB Kober	8.0	60.7	131.3	79.4	1.65	23.3	7.9	3.43
Ramsey	6.9	60.7	111.7	73.8	1.52	22.6	7.6	3.39
161-49	6.7	59.2	112.9	72.5	1.56	22.6	7.5	3.44
5C Teleki	6.7	55.4	119.4	74.5	1.59	23.0	7.9	3.46
Ungrafted	6.4	58.0	112.1	73.4	1.53	23.4	7.7	3.43
101-14	6.2	61.9	100.9	69.4	1.47	23.8	7.3	3.45
110 Richter	5.4	50.0	109.2	69.1	1.57	23.1	7.5	3.42
Riparia Gloire	5.3	53.9	100.1	67.6	1.48	23.4	6.8	3.46
LSD 5%	0.8	5.8	8.5	NS	0.08	0.4	0.5	NS

Table 13

Merlot FVD3V14, Ararat, 5 years

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
Schwarzmann	3.60	30.3	112.1	86.1	1.30	23.4	6.46	3.47
99 Richter	3.55	31.2	108.1	87.4	1.23	23.0	6.76	3.41
5C Teleki	3.50	30.1	111.5	86.7	1.29	23.1	6.35	3.45
Ungrafted	3.12	29.3	104.0	81.5	1.25	23.2	6.92	3.40
LSD (5%)	NS	NS	NS	NS	0.04	NS	0.22	0.04

Table 14

Muscadelle FVC1V15, Rutherglen, Duplex Soil, pre and post phylloxera, 8 years data

Rootstock	Yield kg / vine Pre-phylloxera Mean first 4 years	Yield kg / vine Post-phylloxera Mean second 4 years
ARG No1	8.6	12.1
5BB Kober	6.9	11.8
K51-32	6.9	10.8
Schwarzmann	7.5	10.4
1613	6.7	10.3
Harmony	5.7	10.2
110 Richter	6.1	9.5
Ungrafted	8.3	8.4

Table 15

Pinot noir FVD5V12, Drumborg, Clay Loam, mean 3 years

	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
Ramsey	5.2	53.7	97.0	84.4	1.19	20.5	7.7	3.35
Lider 106-38	5.1	56.3	90.8	76.7	1.16	21.0	7.5	3.35
140 Ruggeri	5.0	52.4	90.5	79.0	1.13	20.6	7.9	3.37
Ungrafted	4.9	55.3	86.8	74.3	1.15	20.4	7.8	3.36
Schwarzmann	4.8	49.4	94.3	82.2	1.16	20.7	7.3	3.38
5BB Kober	4.5	45.7	96.8	78.6	1.21	20.7	8.2	3.38
99 Richter	4.1	46.5	85.6	73.8	1.17	20.6	7.4	3.38
5A Teleki (5BB Kober)	4.0	44.9	87.2	71.2	1.19	20.5	8.0	3.40
Lider 171-32	3.6	44.5	77.2	65.9	1.14	20.3	8.6	3.36
LSD (5%)	NA	NA	NA	NA	NA	NA	NA	NA
Number of years	3	3	3	3	4	4	4	4

Table 16

Pinot noir FVD2V5 (Wadenswil B111), Great Western, mean 4 years

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
Teleki C	7.4	68.0	110.4	104.3	1.08	22.9	5.63	3.49
Ramsey	7.0	61.5	112.3	101.7	1.11	23.3	5.58	3.45
140 Ruggeri	6.4	59.1	108.1	104.7	1.04	23.0	5.39	3.52
99 Richter	6.3	58.6	106.7	107.2	1.00	22.7	5.73	3.52
5A Teleki (5BB Kober)	6.2	57.7	106.2	102.0	1.06	22.9	5.68	3.46
Lider 171-13	6.1	57.9	102.3	90.8	1.13	23.2	5.84	3.43
Ungrafted	5.9	57.0	105.1	97.7	1.08	23.0	5.62	3.44
Meunier / 5BB Kober	5.7	58.9	100.5	89.8	1.13	23.2	5.36	3.56
Freedom	5.7	56.7	101.0	92.2	1.12	23.4	5.75	3.49
5BB Kober	5.6	55.0	104.8	106.1	1.00	22.9	5.43	3.50
Lider 122-16	5.4	52.3	104.9	101.1	1.04	23.7	5.84	3.51
101-14	5.0	51.1	98.0	99.8	1.01	23.4	5.18	3.54
LSD (5%)	0.8	5.9	8.5	7.8	0.06	0.5	0.28	0.05

Table 17

Pinot noir FVD2V5 Mornington Peninsula, mean 4 years

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
Ungrafted	5.6	97.5	59.1	54.8	1.07	21.6	7.19	3.45
99 Richter	4.2	79.1	54.0	50.7	1.07	21.9	7.99	3.51
3306	3.9	76.7	51.0	46.9	1.09	21.7	7.62	3.49
Ramsey	3.8	75.8	49.0	42.7	1.15	21.3	7.92	3.45
110 Richter	3.7	67.8	56.4	55.8	1.05	21.2	7.32	3.46
Schwarzmann	3.6	69.4	54.7	50.7	1.09	21.5	7.80	3.48
5BB Kober	3.6	75.1	48.9	41.2	1.18	21.8	8.21	3.46
LSD (5%)	0.7	9.6	6.9	6.8	0.06	NS	0.39	NS

Table 18

Pinot noir FVD2V5, Coghills Creek, heavy clay soil. Comments: Soil prone to waterlogging, several rootstocks could not be established, ie. 99 Richter, 101-14 and Riparia Gloire

	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
Ungrafted	5.8	52.0	113.3	105.8	1.09	20.7	6.5	3.33
Fercal	4.4	42.7	100.9	92.6	1.10	21.6	6.4	3.35
3309	4.2	43.9	92.7	90.6	1.04	19.7	6.4	3.28
Schwarzmann	4.1	40.9	95.9	97.2	1.01	19.1	6.2	3.35
3306	3.8	40.0	92.1	97.6	0.98	19.8	6.1	3.33
420A	3.1	34.6	86.6	89.0	0.98	19.5	6.0	3.35
110 Richter	2.9	33.5	84.6	84.7	1.01	20.8	6.2	3.32
LSD (5%)	0.6	5.4	9.5	10.2	0.06	1.1	0.3	NS
Years of data	3	3	3	3	3	3	3	3

Table 19

Pinot noir MV6, Porepunkah, 1 year

	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
Ramsey	13.2	112.9	117.6	78.8	1.51	21.3	6.6	3.47
5BB Kober	11.5	104.3	109.7	73.5	1.50	21.9	6.6	3.55
Ungrafted	10.1	106.3	93.6	68.4	1.37	22.7	6.6	3.63
101-14	9.7	106.9	90.2	67.8	1.35	23.3	5.8	3.62
Riparia Gloire	7.0	75.1	92.6	70.5	1.32	23.9	6.2	3.68
LSD (5%)	1.9	14.4	9.4	7.4	0.12	1.1	0.4	0.06

Table 20

Shiraz SA 1654, Wahgunyah, sandy loam, replant, mean 8 years, phylloxera and nematodes

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
5BB Kober	11.7	130.3	92.4	61.6	1.40	22.5	6.0	3.68
5C Teleki	11.1	124.9	90.9	60.4	1.38	22.3	5.9	3.67
ARG No 1	10.7	128.6	85.7	60.9	1.28	22.0	5.8	3.63
Rupestris du Lot	10.5	121.3	87.9	61.8	1.39	22.4	5.9	3.74
5A Teleki (5BB Kober)	10.1	116.4	90.3	62.8	1.36	22.3	6.0	3.65
Schwarzmann	10.1	116.2	90.1	59.4	1.36	22.4	5.7	3.69
110 Richter	9.7	111.5	88.6	58.3	1.34	22.4	5.7	3.61
Harmony	9.1	118.3	81.2	56.2	1.30	22.8	6.0	3.68
Ungrafted	8.6	112.5	74.6	52.1	1.23	22.7	5.8	3.63
LSD (5%)	1.1	9.5	6.6	4.1	0.06	NS	0.2	0.04

Table 21

Shiraz Bests clone, Great Western, 3 years

Rootstock	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
SO4	4.2	43.9	98.3	71.5	1.37	22.0	5.1	3.87
99 Richter	3.5	37.7	93.5	67.6	1.38	22.0	5.1	3.93
Ungrafted	3.3	40.4	81.3	60.7	1.34	22.3	5.1	3.92
1103 Paulsen	3.1	37.4	84.5	61.8	1.36	23.0	5.0	4.02
LSD (5%)	0.4	3.5	5.7	4.3	NS	0.5	NS	0.05

Provisional Clonal Trial Results

Table 22

Cabernet sauvignon, Nagambie, Comment: Un-replicated comparison, further details in Whiting and Godden 1988. FV = Foundation Vineyard; SA = South Australia; INRA = Institut National de la Recherche Agronomique.

	Yield kg/vine	Bunch nos. per vine	Bunch wt G	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
FVG9V3	9.0	95	93			21.2	7.9	3.4
INRA 5186	8.6	100	83			22.3	7.2	3.4
SA 125	7.3	104	71			22.5	7.6	3.5
SA 126	6.3	87	70			22.9	7.6	3.6
INRA 5325	5.9	85	66			23.5	7.0	3.5
INRA 5197	4.4	88	46			23.8	6.7	3.4
Years of data	6	6	6			4	3	3

Table 23

Cabernet Sauvignon, Mildura, sandy loam, mean 5 years. Comment: Clonal source was Seppelts, Great Western (SGW)

Clone	Yield kg/vine	Bunch nos. per vine	Bunch wt G	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
SGW 16-31	11.1	180.8	67.4	73.9	0.92	21.7	6.5	3.53
SGW 14-12	11.0	182.0	68.7	75.4	0.93	22.1	6.5	3.52
SGW 16-06	10.8	186.5	65.2	71.8	0.91	21.7	6.3	3.55
SGW 13-28	10.7	184.1	63.4	72.8	0.90	22.2	6.7	3.52
SA 125	10.5	178.8	65.4	75.4	0.87	22.1	6.5	3.55
SGW 16-35	10.4	192.8	63.2	71.8	0.89	22.0	6.4	3.56
SGW 16-09	10.2	178.0	65.8	74.2	0.90	22.2	6.3	3.56
SGW 10-14	10.0	180.4	64.8	72.5	0.90	22.0	6.2	3.56
SGW 14-49	9.4	168.3	63.7	71.4	0.91	22.4	6.3	3.57
SGW 14-09	8.4	150.3	62.3	76.6	0.82	22.1	6.5	3.55
SGW 15-32	8.0	183.1	50.8	62.3	0.83	22.1	6.7	3.50
LSD (5%)	0.7	10.8	4.0	4.5	0.02	0.3	0.2	0.03

Table 24

Chardonnay, Nagambie, duplex soil. Comment: Un-replicated comparison, further details in Whiting and Godden 1988

	Yield kg/vine	Bunch nos. per vine	Bunch wt G	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
FVI10V5	11.0	86	127			21.9	8.2	3.4
Penfold 58	9.9	90	107			21.7	8.2	3.4
OFF1V3	6.8	99	67			21.7	8.4	3.4
Years of data	6	6	6			5	5	5

Table 25

Chardonnay, Drumborg, clay loam, mean 4 years

Clone	Yield kg/vine	Bunch nos. per vine	Bunch wt G	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
FVG9V5	5.8	38.6	148.8	128	1.18	17.7	10.8	3.12
FVG9V7	5.6	36.6	154.2	133	1.16	17.9	10.2	3.13
FVI10 V5	5.3	40.9	131.6	113	1.17	19.0	9.7	3.13
FVI10 V3	4.2	40.6	101.9	89	1.15	19.6	8.7	3.17
FVI10 V1	3.9	38.6	101.3	87	1.16	20.0	8.3	3.19
LSD 5%	0.8	NS	16.0	14	NS	0.5	0.6	0.02

Table 26

Dolcetto, Mildura, sandy loam, Comment: Clones selected from Bests, Great Western (BGW)

Clone	Yield kg/vine	Bunch nos. per vine	Bunch wt G	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
BGW 0379	10.9	109	133.6	88	1.55	17.7	5.5	3.53
BGW 0602	10.7	108	130.9	86	1.55	18.0	5.5	3.53
BGW 0504	10.5	110	127.7	86	1.51	18.1	5.3	3.53
BGW 0508	9.5	106	122.8	77	1.62	18.7	5.5	3.53
BGW 1003	9.2	97	126.1	81	1.56	18.6	5.4	3.56
LSD (5%)	NS	NS	NS	NS	NS	NS	NS	NS
Years of data	4	2	2	2	2	2	2	2

Table 27

Dolcetto, Mildura, sandy loam, Comment: Clones selected from Seppelts, Great Western (SGW)

Clone	Yield kg/vine	Bunch nos. per vine	Bunch wt G	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
SGW 0539	12.7	124.5	118.5	76	1.56	17.3	6.3	3.46
SGW 1034	12.1	109.4	130.9	80	1.64	18.3	6.1	3.51
SGW 1041	11.0	107.6	122.1	79	1.57	18.7	5.9	3.49
SGW 1232	10.7	112.7	115.1	71	1.63	18.2	5.7	3.53
SGW 1040	10.5	97.5	116.2	76	1.56	18.4	6.2	3.51
LSD (5%)	1.3	13.9	NS	NS	NS	0.8	0.4	NS
Years of data	4	2	2	2	2	2	2	2

Table 28

Gewurztraminer, Delatite, mean 3 years

Clone	Yield kg/vine	Bunch nos. per vine	Bunch wt G	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
Traminer FVC3V15	5.1	88.8	54.8	48.7	1.2	21.6	4.0	3.9
Traminer Pen 58	5.1	94.6	51.3	48.5	1.1	21.7	4.0	4.0
Traminer 456	4.8	102.1	45.9	43.2	1.1	22.0	3.9	4.0
Gewurztraminer Pen 58	4.3	81.9	49.8	47.5	1.1	21.5	3.9	4.0
Traminer FVH8V9	3.7	69.5	51.6	49.7	1.1	21.7	3.9	4.0
LSD (5%)	0.9	12.4	5.6	4.5	NS	NS	NS	NS

Table 29

Merlot, Mornington Peninsula, mean 3 years. Comment: FV = Foundation Vineyard; RVC = Rutherglen Viticultural Collection; RBK = Ridley Bell Katunga

	Yield kg/vine	Bunch nos. per vine	Bunch wt G	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
FVD3V14	5.6	70	75	63	1.22	21.7	7.2	3.42
FVD3V5	5.4	74	68	65	1.11	21.5	7.5	3.34
FVD3V7	5.2	71	70	60	1.19	22.0	6.9	3.40
RVC13	5.0	72	66	66	1.06	22.4	7.3	3.35
RBK1	4.6	68	63	57	1.17	21.6	7.5	3.37
RBK3	4.5	73	60	58	1.14	21.0	8.0	3.37
RBK2	3.7	62	56	52	1.16	21.3	7.9	3.32
LSD (5%)	0.6	NS	5	5	0.07	0.3	0.3	0.06

Table 30

Pinot noir, Great Western, duplex soil, mean 3 years. Comment: Full details of this trial are available in Whiting and Hardie 1990.

Clone	Yield kg/vine	Bunch nos. per vine	Bunch wt G	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
FVD2V5 (B111)	3.2	51	61	117	0.55	21.5	7.5	3.44
FVD5V12	2.9	41	70	121	0.60	21.9	7.3	3.47
MV6	2.5	50	50	86	0.60	23.1	6.9	3.63
FVD2V6 (B110/16)	2.1	42	51	102	0.51	21.7	7.7	3.46
FVG5V15 (B110/16)	2.1	39	53	109	0.50	21.8	8.1	3.46
LSD (5%)	NA	NA	NA	NA	NA	NA	NA	NA

Table 31

Pinot noir, Drumborg, clay loam, mean 3 years

Clone	Yield kg/vine	Bunch nos. per vine	Bunch wt G	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
Mariafeld	5.7	47.7	118.3	97.1	1.21	19.5	9.2	3.22
Gm18	5.4	53.8	96.4	91.1	1.05	19.6	8.6	3.27
FVG5V15 (B110/16)	5.2	50.0	98.4	89.0	1.12	19.2	9.4	3.26
FVD2V5 (B111)	4.8	58.4	78.7	70.2	1.11	20.0	7.5	3.31
Meunier FVH10V5	4.4	52.1	81.0	76.7	1.07	20.3	7.6	3.33
FVF6V7	4.1	53.4	73.7	66.9	1.09	20.6	7.5	3.40
FVG8V7	4.1	54.7	70.8	64.8	1.06	21.3	7.8	3.40
FVD5V12	4.0	48.0	82.2	74.7	1.08	20.0	8.6	3.29
FVG8V3	3.8	48.7	76.6	73.5	1.03	20.9	7.2	3.42
MV6	3.5	55.9	59.9	54.8	1.08	20.6	8.0	3.39
BM R26V5	2.4	49.2	50.2	49.4	1.00	21.3	7.6	3.43
LSD (5%)	0.7	6.3	8.1	7.9	0.06	0.6	0.4	0.03

Table 32

Pinot noir, Great Western, 3 years

Clone	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
FVD5V12	7.7	79.4	96.5	101.7	0.96	20.9	5.7	3.52
Gm 18	7.7	78.3	96.7	100.7	0.98	21.6	6.5	3.48
Mariafeld	7.5	73.6	101.6	88.5	1.14	21.9	7.0	3.39
FVD2V5 (B111)	7.1	79.5	89.8	88.6	1.01	21.5	6.1	3.52
FVG8V3	6.4	73.8	86.9	83.9	1.06	22.1	5.6	3.62
FVF6V7	5.9	79.0	77.0	80.1	0.95	22.8	5.6	3.63
Meunier FVH10V5	5.4	70.1	76.6	73.4	1.05	22.7	5.5	3.69
MV6	5.4	73.9	73.4	75.2	1.01	22.2	6.1	3.56
LSD (5%)	1.1	NS	8.7	8.2	0.07	0.7	0.4	0.06

Table 33

Riesling, Nagambie. Comment: Un-replicated comparison, further details in Whiting and Godden 1988

	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar ˚Brix	Titratable acid g/l	pH
FVG9V15	15.9	113	141			19.6	8.6	3.2
FVI10V15	14.7	109	134			19.7	8.2	3.3
FVF8V13	13.7	123	110			18.8	8.6	3.3
FVI10V14	12.9	109	119			19.5	8.0	3.3
FVD2V4 (Gm 110)	11.2	120	94			17.3	9.2	3.1
Years of data	6	6	6			5	4	4

Table 34

Sauvignon blanc, Dookie, clay loam, mean 1 year

Clone	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar ˚Brix	Titratable acid g/l	pH
FV H5V10	9.1		113		1.23	23.7		
SA 79	7.5		82		1.29	26.0		
SA 33	5.4		76		1.22	26.1		
SA 132	5.1		74		1.21	27.0		
SA 47	4.7		83		1.32	27.0		
SA 90	4.4		78		1.25	26.9		
SA 72	4.3		69		1.20	26.8		
LSD (5%)	NA		NA		NA	NA		

Table 35

Shiraz, Ararat, Yellow duplex, mean 4 years

	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar ˚Brix	Titratable acid g/l	pH
CSIRO R7V1	5.2	46.9	106	81	1.31	22.9	7.3	3.39
ESA 3021	5.1	46.2	106	82	1.30	23.0	7.6	3.35
BVRC 12	4.8	45.7	103	81	1.29	23.6	7.0	3.36
NSW 15	4.8	45.5	101	77	1.31	23.1	7.4	3.36
SA 1654	4.7	45.2	101	76	1.33	23.2	7.1	3.35
CW 73-16	4.6	43.6	102	81	1.27	23.5	7.1	3.39
NSW 23	4.5	43.7	99	77	1.28	23.6	7.0	3.38
Tahbilk R6W	4.4	45.1	93	72	1.31	24.2	7.3	3.41
Tahbilk R2E	4.4	41.5	102	79	1.30	23.4	6.9	3.39
BVRC 30	4.4	43.7	99	77	1.29	23.4	7.2	3.37
Rutherglen ‘Caracosa’	4.2	43.4	95	74	1.28	23.2	7.0	3.40
NSW 10	3.9	41.0	94	74	1.27	24.0	7.0	3.39
Tahbilk R7V3E	3.3	37.8	85	69	1.25	24.0	6.9	3.41
LSD 5%	0.6	5.2	6	5	0.04	0.5	0.3	0.03

Table 36

Shiraz, Great Western, 3 years

	Yield Kg/vine	Bunch nos. Per vine	Bunch wt g	Berry nos. Per bunch	Berry wt g	Sugar ˚Brix	Titratable acid G/L	pH
NSW 15	4.6	43.0	108.8	76.0	1.43	22.0	5.2	3.81
NSW 23	4.4	45.5	99.2	71.1	1.41	22.8	5.0	3.84
NSW 10	4.4	41.4	104.2	77.0	1.35	22.7	4.9	3.75
BVRC 12	4.0	42.5	94.9	65.6	1.46	23.0	4.8	3.83
BVRC 30	3.8	42.5	92.4	64.4	1.44	23.0	5.1	3.76
Bests	3.7	42.8	87.0	61.8	1.41	22.6	5.1	3.83
LSD (5%)	0.5	NS	7.4	5.4	0.04	NS	NS	NS

Table 37

Shiraz, Mildura, sandy loam, 4 years. Comment: Clones selected from old vineyards at Bests Wines Great Western (BGW) and Bests Wines Tresco (BWT).

Clone	Yield kg/vine	Bunch nos. per vine	Bunch wt g	Berry nos. per bunch	Berry wt g	Sugar °Brix	Titratable acid g/l	pH
CSIRO R7V1	14.5	150.5	112.2	85.9	1.28	22.0	5.4	4.02
BWT 0879	13.8	136.7	116.0	88.2	1.33	21.9	5.4	3.96
NSW 15	13.2	128.9	116.6	88.9	1.31	21.4	5.5	3.95
BWT 0352	12.6	126.7	117.6	87.8	1.34	21.8	5.4	4.01
BWT 2253	12.6	137.3	105.0	80.9	1.32	22.0	5.4	3.95
BWT 1245	12.0	116.6	112.4	86.1	1.30	21.8	5.5	3.97
BGW 2033	12.0	118.3	116.5	90.0	1.30	21.7	5.5	3.95
BGW 2027	11.9	116.3	116.4	88.6	1.31	22.0	5.5	3.93
BWT 1033	11.7	116.1	114.5	89.6	1.29	22.0	5.5	3.98
BWT 0329	11.7	111.4	112.6	89.9	1.27	22.2	5.3	3.99
NSW 23	11.4	116.4	109.6	83.3	1.32	22.5	5.5	4.04
NSW 19	11.4	120.1	107.3	82.8	1.30	22.4	5.4	4.00
SA 1654	11.3	109.4	116.9	88.8	1.33	22.4	5.6	4.01
BWT 2152	11.3	116.0	106.2	83.2	1.28	22.2	5.4	4.03
NSW 10	11.3	119.5	106.4	82.9	1.27	22.5	5.5	3.96
BGW 2111	11.1	111.5	111.1	86.3	1.30	22.4	5.4	4.00
BGW 2132	11.1	115.8	105.3	82.7	1.28	22.3	5.3	3.97
BWT 0233	10.9	103.1	120.6	90.7	1.34	22.6	5.5	4.00
SA 712	10.9	111.4	114.2	85.8	1.35	22.3	5.6	3.97
BGW 2014	10.8	110.1	106.3	81.8	1.28	22.2	5.5	3.97
BWT 0875	10.6	106.1	111.8	84.9	1.29	22.8	5.5	4.06
BWT 0325	10.6	109.7	106.4	82.4	1.30	22.4	5.5	3.99
BWT 0924	10.5	107.7	115.3	90.7	1.27	22.1	5.5	3.96
BGW 2052	10.3	103.1	108.2	83.0	1.32	22.4	5.2	3.99
BGW 2099	10.2	108.6	102.9	78.0	1.32	22.0	5.4	3.98
BGW 2118	9.9	116.3	99.7	78.7	1.30	22.5	5.6	3.99
SA 1127	9.8	102.0	105.7	84.4	1.28	22.1	5.3	3.97
BGW 2026	9.7	101.3	100.3	80.0	1.24	21.9	5.3	4.00
BGW 2022	9.7	95.1	104.8	80.1	1.29	21.5	5.6	3.95
BGW 2104	9.4	88.8	104.3	82.7	1.26	21.8	5.3	3.97
LSD (5%)	1.3	14.2	8.6	6.5	0.06	NS	NS	0.06

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