Effect of Rootstock on the Composition and Quality of Wines from the Scion Chardonnay

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Abstract

Significant differences in Chardonnay fruit yield wereobserved with different rootstocks. The rootstock Ramsey produced in significantly higher yields than the other three rootstocks, Teleki 5C, Richter 140, Schwarzmann, and ungrafted vines in two out of the three years. Ungrafted vines produced significantly lower yields than all the rootstocks in each of the three years.

The rootstock Schwarzmann resulted in Chardonnay musts and wine with high pH, whilst ungrafted vines and vines grafted onto Teleki 5C produced low pH must and wine. Ramsey produced significantly higher juice potasium, malate and titratable acidity than most other rootsocks in two out of three years.

The white wines produced from grapes grown on each of the rootstocks and ungrafted vines were evaluated by a panel of 7 to 8 experienced judges and were found to be similar in quality. In view of this, where consideration is being given to planting on rootstock, it would appear reasonable to use the more productive rootstock Ramsey.

Introduction

Rootstocks have been primarily utilized by viticulturists to combat the effects of the grape louse phylloxera. However certain rootstocks also provides nematode resistance, a feature which is of particular importance when replanting a vineyard. In South Australia, in the absence of phylloxera, the nematode resistant rootstocks are of particular importance (Herberg et al. 1986). A second aspect in the use of rootstocks is the enhanced vigour that the stocks impart to the scion variety (Archer and Fouche 1987).

Whilst all these features have resulted in improved vine performance and hence economic viability, there has been some concern about the quality of the fruit produced on these stocks (Ewart and Sitters 1989). Hale and Brien (1978) found that Shiraz and Sultana vines at Merbein grafted onto Ramsey and Dog Ridge had higher pH and potassium levels than fruit from ungrafted vines. An assessment of the wines from this trial showed a preference for wines from ungrafted vines. High pH and potassium levels in the must have been previously correlated with poor wine quality (Somers 1975), a fact which is supported by the findings of Hale and Brien (1978). Rühl et al. (1988) in a study of the effect of rootstocks on must composition in 3 wine-growing regions found that, with the exception of the scion Chardonnay, use of rootstocks resulted in higher pH must.

The climatic and soil conditions would appear to strongly influence the outcome of a rootstock evaluation trial. This study evaluates the effects of a number of rootstocks at McLaren Vale, SA on Chardonnay must and wine composition, and the sensory properties of the resultant wines.

Table 1. Identification numbers and species of rootstocks used

Rootstock	Australian accession list number	Species
Ramsey	I.S.66.2065	*V. champini*
1613	I.S.74.2066	*V. labrusca-riparia-vinifera* × *V. longini*
Harmony	I.S.70.2134	*V. champini* × 1613
Schwarzmann	A.S.74.2257	*V. rupestris* × *V. riparia*
Teleki 5C (imported as SO4)	I.S.74.2136	*V. berlandieri* × *V. riparia*
ARG1	I.S.74.2046	*V. vinifera* × *V. rupestris*
1202 Couderc	I.S.74.2135	*V. vinifera* × *V. rupestris*
5BB Kober	I.S.74.8057	*V. berlandieri* × *V. riparia*
Richter 110	I.S.74.2083	*V. berlandieri* × *V. rupestris*
420A Millardet et de Grasset	–	*V. berlandieri* × *V. riparia*
Rupestris St George	I.S.74.2165	*V. rupestris*
1616	I.S.66.2082	*V. longii* × *V. riparia*
Teleki 5A	I.S.75.2133	*V. berlandieri* × *V. riparia*
101–14 Millardet et de Grasset	–	*V. riparia* × *V. rupestris*
Ruggeri 140	I.S.76.8257	*V. berlandieri* × *V. rupestris*
Ungrafted	I.S.73.8127	*V. vinifera* cv. Chardonnay

MATERIALS AND METHODS

Chardonnay scions of a single selection were bench-grafted to the rootstocks listed in Table 1 and planted as potted vines in August 1980. A complete randomized block of 12 replicates with three-vine plots was used. Only the centre vine in each plot was measured, the other two being buffers. The experimental block was buffered on either side with a single row of grafted vines. The site, on a deep (>2 m) medium-textured sand, was drip irrigated on an infrequent basis with total annual irrigation being less than 100 mm. Vines were trained on a single bilateral cordon, and once established pruned to about 70 buds per vine.

Yield measurements commenced in 1985. At harvest in 1988 fruit from vines grafted to Ramsey, Teleki 5C, Ruggeri 140, Schwarzmann and ungrafted vines was retained for small lot winemaking. These stocks were chosen so as to provide a range of vine vigour and yield, from high vigour, high yield (Ramsey) to low vigour, low yield (ungrafted). All fruit from these combinations was harvested on the one day in each of 3 consecutive years (26/2/88, 20/2/89, 8/3/90)

The grapes were processed utilizing the standard techniques for small lot winemaking used at the Grape and Wine Research Unit (Ewart and Sitters 1991).

Must analyses were carried out for total soluble solids (TSS, °Brix), titratable acidity and pH, while aliquots of must with 1:5 dilutions were frozen for later analyses of malate, tartrate and potassium.

The pH and titratable acidity were analysed using an automated end-point titration system. TSS was analysed by refractometer and potassium was measured by flame photometer. Malate and tartrate were determined by HPLC using an Aminex HPX87 cation exchange column. Alcohol was determined by ebulliometer and reducing sugar by the Lane and Eynon method (Amerine and Ough 1980). In 1990, total hydroxycinnamates was determined using the method of Somers (1991).

Chemical data was first analysed using two-way ANOVA to determine if any interaction occurred between rootstock and year, for each chemical parameter. If interaction existed, one-way ANOVA was separately performed for each year.

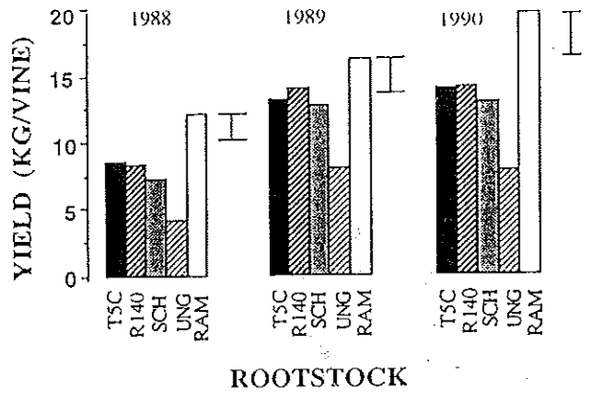

Figure 1 Mean yield for scion Chardonnay grafted to 5 different rootstocks planted at McLaren Vale (SA) for the 3 years of the study. Vertical lines represent LSD values at 5 %. (T5C = Teleki 5C; R140 = Ruggeri 140; Sch = Schwarzmann; UNG = Ungrafted; Ram = Ramsey)

Differences between means were determined using Fischer's least significant difference test ($\alpha = 0.05$). Linear correlation analysis was also performed between mean yield and all mean chemical analyses. All data analyses were performed using SAS (Statistical Analysis System, Carey, NC).

Sensory analysis was carried out by experienced judges, being either staff from the Department of Horticulture, Viticulture and Oenology or wine industry personnel (Table 2).

All tasting was performed in a white-painted room with each judge separated by a partition. The wines were presented in 6 groups of 5 wines, such that each group contained a replicate of each of the rootstocks. Thirty mL of wine was presented in a glass assigned with a random two digit number. The presentation order to each judge was randomized and all wines were examined twice over the period of the tasting to allow estimation of judge performance and reliability. The judge's only information was that the wines were Chardonnay, and wines were to be scored using the Australian

Table 2. Significance levels for between groups (rootstocks) and repeat measure (years) ANOVA

	Chemical analyses								
	pH	TSS	T.A.	Tartrate	Malate	Potassium	Wine pH	Wine T.A.	Alcohol
Rootstock x Year	ns	ns	ns	ns	ns	ns	ns	ns	ns
Rootstock	**	ns	***	ns	**	**	***	***	ns
Year	***	***	***	***	***	***	***	***	**

*** $p < 0.0001$ ** $p < 0.01$ ns = not significant

Table 3. Composition of the must and wine from each of the five rootstocks over three years

	Must						Wine		
Rootstock	pH	T.A. (g/L H_2T)	TSS (o Brix)	Tartrate (g/L)	Malate (g/L)	Potassium (mg/L)	pH	T.A. (g/L H_2T)	Alcohol (% v/v)
Teleki 5C	3.29 bc	7.17 ab	23.2	7.14	2.24bc	1388ab	3.14 b	6.41 a	13.5
Ruggeri 140	3.31 b	7.46 a	23.8	7.09	2.63ab	1329bc	3.23 a	6.44 a	13.8
Schwarzmann	3.34 a	6.72 b	23.9	6.78	2.14c	1300c	3.25 a	5.86 b	13.6
Ungrafted	3.30 bc	6.67 b	24.1	7.10	1.84c	1358bc	3.17 b	5.94 b	13.9
Ramsey	3.28 c	7.87 a	23.4	7.16	2.90a	1438a	3.22 a	6.61 a	13.4

with 20 point system. The point scoring system assigns a maximum of 3 points for appearance (colour and clarity), 7 points for aroma and 10 points for palate characteristics.

Judge performance measures, as described by Brien et al. (1987), were determined by ANOVA for each judge's scores using GENSTAT (Rothamstead, UK) (Table 2).

RESULTS

Yield

There were significant differences in yield between rootstocks within years (Figure 1). Ungrafted vines had a lower yield than all other rootstocks, whilst Ramsey had a higher yield than the remaining stocks in 2 out of the 3 years. In 1989 there was no significant difference between Ramsey and the next highest yielding rootstock, Ruggeri 140. No significant differences between the yields of Schwarzmann, Ruggeri 140 and Teleki 5C were found in any year. Significant correlations existed between yield and malate concentration in 1988 ($r = 0.919$, $P < 0.05$) and 1989 ($r = 0.934$, $P < 0.05$).

Must composition

There was no significant year interaction (Table 2). Significant differences over the three years occurred between rootstocks for pH, titratable acidity, malate and potassium concentration. There was no significant difference for TSS and tartrate concentration. The seasonal differences are shown by significant variation in the chemical parameters of the must between years (Table 2).

Table 3 presents the mean must chemical analyses of fruit for all treatments over the 3 year experimental period. Fruit on the rootstock Schwarzmann had a higher must pH than all other rootstocks, followed by Ruggeri 140, which was higher than Ramsey. Juice from the rootstock Ramsey attained the highest titratable acidity, although it was not significantly different from Ruggeri 140 and Teleki 5C. This appears due to the fact that, overall, Ramsey had a higher malate concentration than all other rootstocks, except Ruggeri 140, which in turn was higher than Schwarzmann and ungrafted. With the exception of Schwarzmann, ungrafted fruit had the lowest titratable acidity over the three years. Ramsey had a higher concentration of potassium than ungrafted, Ruggeri 140 and Schwarzmann, but not Teleki 5C. The results by year and by rootstock are presented in Table 5.

Wine analysis

No significant interaction between rootstock and year was found for any of the chemical wine indices (Table 2). Highly significant differences were found between rootstocks for pH and titratable acidity over all three years. The alcohol concentration of wine produced from rootstocks was not significantly different. Ungrafted vines and Teleki 5C produced wine of a lower mean pH than Schwarzmann, Ruggeri 140 and Ramsey. The titratable acidity of wine from fruit grown on Ramsey, Ruggeri 140 and Teleki 5C was significantly higher than ungrafted and Schwarzmann (Table 3). The wine composition results for each year are presented in Table 6

Rootstocks had no effect on total hydroxycinnamates of Chardonnay wines in 1990.

Sensory analysis of wines

In all three years the panellists were unable to detect any treatment differences between wine made from fruit grown on each rootstock. Differences in wine quality scores between

Table 4. Sensory analysis—judge performance statistics

Year	Judge	Reliability Corr R	Discrimination Wines F	Treatments F
1988	1	0.32 ns	1.63 ns	0.73 n
	2	0.10 ns	1.42 ns	2.07 ns
	3	0.03 ns	1.49 ns	1.29 ns
	4	0.20 ns	2.79 ns	2.18 ns
	5	0.50 ns	3.23*	0.45 ns
	6	0.75**	6.63**	0.74 ns
	7	–0.33 ns	0.39 ns	1.15 ns
1989	1	0.31 ns	1.91 ns	1.43 ns
	2	0.08 ns	0.79 ns	0.51 ns
	3	0.77**	7.29**	0.68 ns
	4	0.60*	5.47**	1.33 ns
	5	–0.24 ns	0.86 ns	1.25 ns
	6	0.28 ns	1.52 ns	0.69 ns
	7	–0.01 ns	1.09 ns	1.45 ns
1990	1	0.25 ns	1.8 ns	1.28 ns
	2	0.34 ns	2.13 ns	1.42 ns
	3	0.13 ns	1.19 ns	0.87 ns
	4	0.22 ns	1.53 ns	0.91 ns
	5	0.24 ns	2.02 ns	2.37 ns
	6	0.16 ns	1.33 ns	1.24 ns
	7	0.50 ns	6.20***	1.41 ns
	8	–0.24 ns	0.95 ns	2.69 ns

* Significant at p = 0.05
** Significant at p = 0.01
*** Significant at p = 0.001

ability and discrimination were able to detect small wine replicate differences. Examination of the scores showed this difference to be at maximum 1 point, highlighting the inconsequential quality differences attributable to rootstock.

DISCUSSION

The results indicate that some measures of the fruit composition of the scion variety Chardonnay were affected by the rootstock to which it was grafted. However, little overall difference in the sensory characteristics of wines made from each of these rootstocks was detected.

Rootstocks are considered to have detrimental effects on fruit composition, producing high pH/low titratable acidity musts and thin, flavourless wines when compared with ungrafted vines. This has been reported with Ramsey grafted to the scions Shiraz and Sultana in warm climates (Hale 1977, Hale and Brien 1978).

Over the 3 year period of this trial, fruit from Chardonnay grafted onto the rootstock Schwarzmann had the highest must pH and also gave the highest wine pH, both undesirable oenological features. Chardonnay on the rootstock Ramsey had one of the lowest must pH levels, but had a high wine pH, indicating the effect of high potassium levels on the extent of cation exchange. (Boulton 1980). Cation exchange describes the degree to which sodium and potassium ions have exchanged for protons from the organic acids. High exchange results in high pH.

Fruit from ungrafted vines and vines grafted to Teleki 5C had desirably low must and wine pH. The observation that, when grafted onto the rootstock Ramsey, scion varieties produce fruit with high pH and low titratable acidity was not supported by

Table 5. Must composition by rootstock and year

Year/rootstock	pH	T.A. (g/L as H_2T)	TSS (°Brix)	Tartrate (g/L)	Malate (g/L)	Potassium (g/L)
1988						
Teleki 5C	3.35b	7.8b	24.6	8.4	2.7bc	1583b
Ruggeri 140	3.37ab	8.2ab	24.7	8.3	2.9bc	1550b
Schwarzmann	3.41a	7.7b	24.9	8.1	3.0b	1583b
Ungrafted	3.38ab	7.7b	24.9	8.5	2.3c	1500b
Ramsey	3.33b	9.1a	24.4	8.6	3.7a	1783a
LSD (5%)	0.03	0.9	ns	ns	0.7	160
1989						
Teleki 5C	3.35b	6.9a	22.1	5.7	1.9b	1090
Ruggeri 140	3.38ab	6.9a	22.7	5.5	2.2ab	1070
Schwarzmann	3.41a	6.0b	22.5	5.1	1.6bc	925
Ungrafted	3.37ab	5.6b	23.5	5.5	1.3c	970
Ramsey	3.33b	6.9a	22.5	5.5	2.3a	970
LSD (5%)	0.04	0.6	ns	ns	0.4	ns
1990						
Teleki 5C	3.18	7.0ab	23.2	7.3	2.1	1490ab
Ruggeri 140	3.21	7.3b	24.1	7.5	2.8	1367b
Schwarzmann	3.21	6.5b	24.3	7.1	1.8	1390b
Ungrafted	3.17	6.7b	24.1	7.4	1.9	1400b
Ramsey	3.18	7.7a	23.5	7.4	2.7	1625a
LSD (5%)	ns	0.7	ns	ns	ns	150

Values with the same letter are not significantly different at the 5% level

the variety Riesling grown at Loxton, there was no difference for Ruby Cabernet at Loxton or for Shiraz in the Barossa Valley. Chardonnay in the Barossa however, had higher pH on ungrafted vines than on Ramsey. It would appear that the pH effect is influenced by location and variety, and is probably related to the degree of fruit shading.

Table 6. Wine composition by rootstock and year

Year/Rootstock	pH	T.A. (g/L H_2T)	Alcohol (% v/v)
1988			
Teleki 5C	3.25	6.9	14.5
Ruggeri 140	3.27	7.0	14.7
Schwarzmann	3.35	6.6	14.8
Ungrafted	3.25	6.5	14.8
Ramsey	3.21	7.6	14.2
LSD (5%)	0.05	0.6	ns
1989			
Teleki 5C	3.13	5.8	13.0
Ruggeri 140	3.22	5.7	13.4
Schwarzmann	3.26	5.5	13.3
Ungrafted	3.18	5.2	13.8
Ramsey	3.17	5.9	13.1
LSD (5%)	0.08	0.3	0.5
1990			
Teleki 5C	3.05	6.7	13.2
Ruggeri 140	3.12	6.6	13.5
Schwarzmann	3.17	5.8	13.3
Ungrafted	3.09	6.1	13.4
Ramsey	3.13	6.4	13.3

Our results show that must from Chardonnay grafted onto Schwarzmann had a significantly higher pH than all other stocks, whilst ungrafted vines and those on Ramsey did not significantly differ in pH. The different result in the two locations was probably due to vine stress in the ungrafted vines in the Barossa Valley trial as a result of poor soil composition and the presence of high numbers of nematodes (Stirling 1976). The Barossa Valley vineyard had been replanted in shallow soil over clay with a high nematode population. The ungrafted vines were excessively stressed, whereas all vines in the McLaren Vale trial were in good condition. This result suggests care is needed in generalizing rootstock results from a specific location to a broader context.

The rootstock Ramsey produced fruit which had high levels of titratable acidity, malate and potassium. Rühl et al. (1988) found Chardonnay vines grafted to Ramsey had higher malate concentration but a lower potassium concentration. These elevated malate levels may be due to fruit shading as a result of the high vigour imparted by this stock (Hardie and Cirami 1988). The increased yield corresponding to increased malate levels in 1988 and 1989 is likely to be a vine vigour-induced response; a larger vine produces more crop and a denser canopy. No measures on vine vigour were carried out.

Apart from the desirable effect of low must pH, it is the final wine pH which is important to the wine balance. During white winemaking, if the initial must pH is below pH 3.56 the wine pH will fall during cold stabilization (Iland 1987) due to a combination of the formation of other weak acids and the precipitation of potassium bitartrate. The amount of this pH drop depends on the exchange of potassium ions for protons.

(Boulton 1980). The higher the extent of exchange the higher the final pH. The rootstock Schwarzmann experienced a smaller decrease in wine pH after fermentation compared to the other stocks.

The wines from the 5 different rootstocks showed no major sensory differences when analysed on an individual judge basis. Other work with different scion varieties has indicated that wine from ungrafted vines was considered to be of higher quality than grafted vines (Cirami 1989, Hale and Brien 1978).

A study by Ewart and Sitters (1989) on Chardonnay vines in the Barossa Valley found that in 2 out of 3 years trained judges preferred wine from Ramsey and Schwarzmann over any of the other 4 rootstocks tested. They also found that under conditions of water stress, ungrafted vines suffered defoliation and subsequently reduced wine quality due to sunburnt fruit. On the other hand the grafted vines, due to increased vigour intrinsic in the rootstock, maintained sufficient canopy levels to produce fruit in good condition. The result of Ewart and Sitters (1989) may indicate the value of vigorous rootstocks in a poor vigour location, and stresses the need to match the rootstock to the site to produce a balanced vine.

The McLaren Vale site on deep sands produced vines with adequate vigour; they were neither stressed nor excessively vigorous. It is likely that this resulted in all wines being of similar quality. On the basis of must and wine composition, ungrafted vines and those grafted onto Teleki 5C had the most desirable oenological characteristics–low pH, moderate adicity and good sugar levels—which in the absence of sensory differences would make them the rootstock of choice

However, as the higher yielding Ramsey vines produced wines that were not organoleptically inferior, that rootstock should also be considered on economic grounds. If a lower vigour stock is desired, then the moderate to low vigour Teleki 5C is preferred as in this study it produces must and wine of excellent composition.

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