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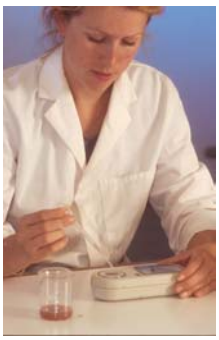
Murray Valley Winegrape Industry Development Committee

The Victorian and Murray Valley Wine Grape Growers Council Inc.
REG. NO. A0010590C

Grape and Wine Research and Development Corporation

Matching rootstock and scion combinations to environmental conditions in the Murray Valley



INTERIM REPORT (1999-2002) to:
GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

Project Number: RT 01/03

Principal Investigator: Dr Mark Krstic

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Research Organisation: Victorian and Murray Valley Winegrape Growers' Council

Date: 30 June 2002

Rootstock Trial

Summary Report

1999/2000
2000/2001
2001/2002

Summary of Results from Year One to Year Three

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Executive Summary

Although rootstocks have been used in the wine industry for many years, there is a lack of scientific information at a regional level about new and existing rootstocks in the Sunraysia region. This project was set up to increase the information available about the performance of Chardonnay, Shiraz and Cabernet Sauvignon grafted to commonly used, and new rootstocks. The rootstocks examined were Ramsey, 1103 Paulsen, 140 Ruggeri, 5BB Kober, 101-14 Millardet, 5C Teleki, Fercal and 116-60 Lider. Fercal is a new rootstock currently under a testing agreement and is not commercially available yet.

There are many advantages of using rootstocks in viticulture. These include protection from the effects of soil-borne pests such as phylloxera and nematodes. Many rootstocks are well adapted to particular soil types and some may be used to overcome vineyard problems such as drought and salinity. The use of rootstocks can also influence vine vigour, and may have important implications on canopy light interception, fungal pathogens and winegrape quality.

The following assessments were conducted throughout the 2001/2002 growing season. They are as follows:

- Nematode status of soil at each rootstock and scion combination (2 vines of each)
- Pruning weights (Chardonnay only)
- Bud Burst counts
- Sugar and berry weight testing
- Winegrape quality analysis: Brix, pH, Titratable Acidity, colour, phenolics, chloride, sodium, potassium and nitrogen

The best performing rootstocks were selected at the end of each season based on a multi-factorial comparison of all the features associated with each stock. This selection process is subjective, but weighted toward those rootstocks which have produced good economic yields for the grower and also possess the desirable characteristics for wine making purposes, ie early ripening to pre-specified Baume level, low pH, high TA, high colour and phenol levels, low sodium, low chloride, low potassium and higher nitrogen levels.

The best performing rootstocks grafted to Shiraz (1999-2002) were:
- **101-14** - early ripening, mid-range yield, small berries, low pH, mid-range TA, high colour and phenolics
- **1103 Paulsen** - earlier ripening, mid-range yield, small berries, mid-range colour and phenolics

The best performing rootstocks grafted to Chardonnay (1999-2002) were:
- **101-14** - early ripening, good yield, mid-sized berries, low pH, high TA, lower phenolics
- **116-60 Lider** - earlier ripening, high yield, mid-sized berries, low pH, high TA, lower phenolics
- **1103 Paulsen** - high yield, mid-sized berries, low pH, high TA, lower phenolics

The best performing rootstocks grafted to Cabernet Sauvignon (1999-2002) were:
- **5C Teleki** - mid-range yield, smaller berries, high colour and phenolics
- **140 Ruggeri** - mid-range yield, low pH, medium TA, high colour and phenolics
- **101-14** - earlier ripening, mid-range yield, smaller berries, low pH, high TA, high colour and phenolics

Table of Contents

1.0 Background

1.1 Introduction

Rootstocks have been used in Sunraysia for many years. However, there is only a limited amount of information available about the performance of commonly used rootstocks which have been grafted to the major winegrape varieties Chardonnay, Shiraz and Cabernet Sauvignon. In 1996, a project was established in collaboration with the Murray Valley Winegrape Industry Development Committee, the Victorian and Murray Valley Vine Improvement Association (VAMVVIA) and commercial winegrape growers (Barry Avery and Dennis Mills) to examine the performance of a range of rootstocks grown in the Sunraysia district. The rootstocks included Ramsey, 1103 Paulsen, 140 Ruggeri, 5BB Kober, 101-14 Millardet, 5C Teleki and 116-60 Lider. Fercal, a new rootstock currently under plant breeders rights, was also selected. The rootstocks were grafted to the major winegrape varieties Chardonnay, Shiraz and Cabernet Sauvignon.

In November 1999, an evaluation project between the Victorian and Murray Valley Wine Grape Growers Council (VMVWGGC) and the Department of Natural Resources and Environment (NRE, through Agriculture Victoria Services Pty. Ltd.) commenced with additional funding from the Grape and Wine Research and Development Corporation (GWRDC). The principal investigator is Dr Mark Krstic, a senior research scientist in viticulture based at the Sunraysia Horticultural Centre, Irymple.

1.2 Significance to Industry

There are many advantages of using rootstocks in viticulture. These include protection from the effects of soil-borne pests such as phylloxera and nematodes. Also, many rootstocks are well adapted to particular soil types and some may be used to overcome vineyard problems such as drought and salinity. The use of rootstocks can also influence vine vigour, and may have important implications with canopy light interception, fungal plant pathogens and winegrape quality (early ripening, improved colour).

2.0 Objectives

2.1 Project Aims

The aim of this project is to better understand the interaction of rootstock and scion combination on yield and quality parameters within the Sunraysia region. This involved evaluating: yield, winegrape quality, nematode resistance, ripening rates and graft union compatibility/incompatibility.

3.0 Method

In 1996, three trial sites were established with grafted vines supplied from VAMVVIA. One site was located at Gol Gol on Dennis Mills' property, consisting of Shiraz grafted to six different rootstocks. Two sites were located near Robinvale on Barry Averys' property, consisting of the varieties Chardonnay and Cabernet Sauvignon which were grafted to seven different rootstocks.

The Shiraz site consists of three rows running almost east – west. Guard vines were planted on the end of each row. The rootstocks planted were: 101-14, Ramsey, 1103 Paulsen, 5C Teleki, 5BB Kober and 116-60 Lider. A randomised complete block design was used with nine replicates of each rootstock (see Appendix 1 for trial design).

The Chardonnay site consists of four rows running almost north-south. Guard vines were again planted at the end of each row. The rootstocks planted were: 101-14, Ramsey, 1103 Paulsen, 5C Teleki, 5BB Kober, Fercal and 116-60 Lider. A randomised incomplete block design was used with 10-12 replicates of each rootstock (see Appendix 2 for trial design).

The Cabernet Sauvignon site was situated next to the Chardonnay site. The site consisted of 3 rows running almost north-south. Guard vines were planted at the end of each row. The rootstocks planted were: 101-14, Ramsey, 1103 Paulsen, 5C Teleki, 5BB Kober, Fercal and 140 Ruggeri. A randomised incomplete block design was used with 3-10 replicates of each rootstock (see Appendix 3 for trial design). Appendix 4 contains a table of known characteristics for each of the rootstocks to be tested in this trial.

A number of assessments were conducted throughout the growing seasons. These being:

1999/2000:
- Nematode status of soil at each rootstock and scion combination
- Soil analysis
- Graft union assessment
- Maturity and berry weight testing after veraison
- Winegrape quality analysis: Brix, pH, Titratable Acidity, colour, phenolics, chloride, sodium, potassium, and nitrogen
- Statistical analysis

2000/2001:
- Nematode status of soil at each rootstock and scion combination
- Pruning weight measurement (Shiraz only)
- Bud burst assessment
- Maturity and berry weight testing after veraison
- Winegrape quality analysis: Brix, pH, Titratable Acidity, colour, phenolics, chloride, sodium, potassium, and nitrogen
- Statistical analysis

2001/2002:
- Nematode status of soil at each rootstock and scion combination
- Pruning weight measurement (Chardonnay only)
- Bud burst assessment
- Maturity and berry weight testing after veraison
- Winegrape quality analysis: Brix, pH, Titratable Acidity, colour, phenolics, chloride, sodium, potassium, and nitrogen
- Statistical analysis

3.1 Bud Burst Assessments

Bud burst is defined as when at least 50% of the buds that will burst have reached visible green stage (modified E-L stage 5), (Coombe, 1995). Bud burst assessments were conducted in September in 2000 and 2001 by visual assessment of the vines during various growth stages. This was achieved by regular monitoring of vineyards during the bud burst period and recording dates of each rootstock-scion combination.

3.2 Nematode Tests

Soil was collected from each rootstock/scion combination (two replicates of each). Replicates were selected at opposite ends of each site. The soil was collected using a shovel from three positions around each sample vine (within 500mm of the trunk) at a depth of 100-150mm from the soil surface. Soil samples from each sample vine were then combined and placed in a sealed plastic bag and stored at 4^{o}C prior to analysis.

Nematode extraction and counts were conducted by placing 250g of soil on modified Whitehead trays (unperforated Chux^{TM} on fly wire in letter tray, placed inside kitty litter tray) and 600ml of water was added to just wet the soil on the Chux^{TM}. The samples were left undisturbed for 30 hours after which the trays were lifted out of the water, drained for 3 minutes and removed. The water was sieved through a bank of 6 x 40 micron sieves and collected in approximately 100ml of water. This was allowed to settle for 1 hour before the top 60ml of water was gently removed using suction.

The nematodes were counted using 1ml of the sample in a 2.5cm square counting tray. The number of nematodes per 500g of soil were then calculated and the number of nematodes in the two replicates were averaged.

3.3 Pruning Weight Measurements

Pruning weight was only recorded in the Shiraz vineyard at Gol Gol in August 2000 and only in the Chardonnay vineyard at Robinvale in July 2001. Both years the other varieties had been pruned by contractors prior to the research team arriving on site. Pruning weights were collected by hand pruning the middle measurement vine in each plot to imitate mechanical pruning and recording the weight of prunings using field scales.

3.4 Maturity and Berry Weight Testing

Maturity testing commenced in mid-January, by collecting samples on a weekly basis leading up to harvest. Three samples were collected from each rootstock/scion combination at any one time. A sample consisted of five bunches picked from the guard vines within each three vine plot. The middle vine of the three was retained for harvest. The five bunches were collected from the right, left, top, inside right and inside left of the canopy and placed in a plastic bag. Samples were transported in a 50L esky® containing ice packs back to the laboratory, where they were stored at 4°C until analysis could be conducted. Berries were removed from the five bunches, the weight of 100 berries randomly sampled was measured and recorded. These berries were then juiced using mortar and pestle and the °Brix (sugar level) was recorded using a digital refractometer.

3.5 Winegrape Quality Assessments

3.5.1 Field

The aim was to harvest each rootstock/scion combination at a predetermined maturity set by industry (Chardonnay 13 Baume (23.4 °Brix), Shiraz and Cabernet Sauvignon 13.5 Baume (24.3 °Brix)). Because of ripening problems, the target Baume for Cabernet Sauvignon was readjusted to 13. Once a rootstock/scion combination had reached its target Baume, based on maturity testing, harvest was conducted by picking a transect of 1 metre on the middle vine of each particular rootstock/scion combination. Transects were placed alternatively to the left, right and middle of the selected vine. Yield and bunch number per vine was recorded in the field. Average bunch weight was derived by dividing yield per vine by bunch number per vine. A random 20 bunch sample was collected from each harvested plot and placed in a plastic bag. Samples were transported in a 50L esky® containing ice packs back to the laboratory, where they were stored at 4°C until analysis could be conducted.

3.5.2 Laboratory

Berries were removed from each 20 bunch sample and 100 berries randomly sampled and weighed to determine the average berry weight. Juice was removed from the 100 berry sample by crushing with a mortar and pestle, strained and centrifuged at 3500rpm for 10 minutes to remove foreign material. °Brix were recorded on the centrifuged juice sample using an Atago digital refractometer. Juice pH and titratable acidity (TA) were recorded using an auto-titrator. A further 200-400 berries were collected from the original sample, placed in a plastic bag and frozen at –18°C.

At a later date, frozen berry samples were thawed and juiced using a blender. One gram of this homogenate was used for colour (anthocyanin) and phenolic measurements using the (Iland et al. 2000) Spectrophotometer Method. The remaining homogenate was centrifuged and the purified juice used for Chloride (Cl^-), Potassium (K^+), Sodium (Na^+) and Nitrogen (N) analysis. The concentration of Chloride was determined using a Chloride Meter located at CSIRO Plant Industry, Merbein. The Potassium and Sodium concentrations were determined by using the atomic absorption spectrophotometer located at CSIRO Plant Industry, Merbein. The percentage Nitrogen in the juice was determined using the Leco™ combustion analyser at CSIRO Plant Industry, Merbein.

3.6 Statistical Analysis

Results were statistically analysed using Genstat 5, version 4.1. The Shiraz trial was analysed using ANOVA whereas the Chardonnay and Cabernet Sauvignon sites were analysed using REML analysis to take account of the unbalanced design.

4.0 Results and Discussion

4.1 Bud Burst (BB) Assessments

4.1.1 Shiraz

Rootstock	Year	BB date
5BB Kober	00/01	19/09/00
	01/02	20/09/01
116-60 Lider	00/01	18/09/00
	01/02	20/09/01
1103 Paulsen	00/01	16/09/00
	01/02	20/09/01
Ramsey	00/01	15/09/00
	01/02	20/09/01
101-14	00/01	19/09/00
	01/02	20/09/01
5C Teleki	00/01	18/09/00
	01/02	20/09/01

4.1.2 Chardonnay

Rootstock	Year	BB date
5BB Kober	00/01	17/09/00
	01/02	11/09/01
116-60 Lider	00/01	17/09/00
	01/02	11/09/01
1103 Paulsen	00/01	17/09/00
	01/02	11/09/01
Ramsey	00/01	17/09/00
	01/02	11/09/01
101-14	00/01	17/09/00
	01/02	11/09/01
5C Teleki	00/01	12/09/00
	01/02	11/09/01
Fercal	00/01	12/09/00
	01/02	11/09/01

4.1.3 Cabernet Sauvignon

Rootstock	Year	BB date
5BB Kober	00/01	22/09/00
	01/02	20/09/01
140 Ruggeri	00/01	22/09/00
	01/02	20/09/01
1103 Paulsen	00/01	22/09/00
	01/02	20/09/01
Ramsey	00/01	22/09/00
	01/02	20/09/01
101-14	00/01	22/09/00
	01/02	20/09/01
5C Teleki	00/01	17/09/00
	01/02	20/09/01
Fercal	00/01	17/09/00
	01/02	20/09/01

In 2000/01 Shiraz grafted Ramsey was the first to undergo budburst (15/9/00), followed by 1103 Paulsen (16/9/00), 5C Teleki (18/9/00) and 116-60 Lider (18/9/00). 5BB Kober and 101-14 (both 19/9/00) were the last rootstocks to experience budburst in Shiraz. There was a 4 day difference in budbust between the Ramsey and the 5BB Kober and 101-14 rootstocks. In 2001/02 all rootstocks grafted to Shiraz burst on approximately the 20/9/01.

In Chardonnay, 5C Teleki and Fercal both were the first to undergo budburst (12/9/00). The remainder of the rootstocks (5BB Kober, Ramsey, 116-60 Lider, 1103 Paulsen and 101-14) underwent budbust 5 days later (17/9/00). In 2001/02 all rootstcoks grafted to Chardonnay burst on approximately the 11/9/01.

In Cabernet Sauvignon, Fercal and 5C Teleki were the first to undergo budburst (17/9/00). The remaining rootstocks (101-14, 1103 Paulsen, 140 Ruggeri, 5BB Kober and Ramsey) underwent budburst five days later (22/9/00). In 2001/02 all rootstocks grafted to Cabernet Sauvignon burst on approximately the 20/9/01.

No budburst data was collected during the 1999/2000 season due to the late start of the project.

4.2 Nematode Tests

The Citrus nematode is considered one of the most pathogenic nematode species on grapes (Pearson and Goheen, 1988). Vigor is remarkably reduced, and susceptible plants do not have the resilience to withstand stressful conditions (Pearson and Goheen, 1988). Yields gradually, and inevitably decline, and vineyards become uneconomical (Pearson and Goheen, 1988).

Root knot nematodes seldon kill vines; more often plants decline in vigour and are more susceptible to stress (Pearson and Goheen, 1988).

Damage caused by Root lesion nematodes is more severe than that caused by root knot nematodes and once decline sets in, vines do not respond to cultural practices aimed at alleviating injury (Pearson and Goheen, 1988).

4.2.1 Shiraz

Rootstock		Average Nematodes / 500g soil				
	Year	Citrus Nematode (*Tylenchulus semipenetrans*)	Root knot nematode (*Meloidogyne* sp.)	Root lesion nematode (*Pratylenchus* sp.[1])	Pin nematode (*Criconemella xenoplax*[2])	Other
5BB Kober	99/00	0	0	698	86	310 *Scutellonema*[3]
	00/01	920	0	0	90	0
	01/02	0	0	50	0	250 *Scutellonema*[3]
116-60 Lider	99/00	0	0	0	0	0
	00/01	0	0	60	0	0
	01/02	0	0	50	0	100 *Scutellonema*[3]
1103 Paulsen	99/00	85	0	252	0	0
	00/01	539	76	50	0	39 *X.americanum*
	01/02	0	0	50	150	0
Ramsey	99/00	0	0	210	0	0
	00/01	0	0	0	0	0
	01/02	0	0	100	0	0
101-14	99/00	0	0	84	126	42 *Scutellonema*[3]
	00/01	1548	0	0	0	0
	01/02	0	0	50	50	0
Teleki 5C	99/00	0	0	1110	473	280 *Scutellonema*[3]
	00/01	0	0	141	47	46 *Paratylenchulus*
	01/02	0	0	0	50	0

4.2.2 Chardonnay

Rootstock		Average Nematodes / 500g soil				
	Year	Citrus Nematode (*Tylenchulus semipenetrans*)	Root knot nematode (*Meloidogyne* sp.)	Root lesion nematode (*Pratylenchus* sp.[1])	Pin nematode (*Criconemella xenoplax*[2])	Other
5BB Kober	99/00	0	0	0	0	0
	00/01	0	0	0	0	0
	01/02	0	0	0	0	0
Fercal	99/00	0	0	0	0	0
	00/01	0	0	0	0	0
	01/02	0	0	0	0	0
1103 Paulsen	99/00	0	0	0	0	0
	00/01	0	0	0	0	0
	01/02	0	0	0	0	0
116-60 Lider	99/00	0	0	41	0	0
	00/01	0	0	0	0	0
	01/02	0	0	0	0	0
Ramsey	99/00	37	0	0	0	0
	00/01	0	0	0	0	0
	01/02	0	0	0	0	0
101-14	99/00	0	0	0	0	37 *Scutellonema*[3]
	00/01	0	0	0	0	0
	01/02	0	0	0	0	0
Teleki 5C	99/00	0	0	250	0	0
	00/01	0	0	46	0	0
	01/02	0	0	0	0	0

4.2.3 Cabernet Sauvignon

Rootstock		Average Nematodes / 500g soil				
	Year	Citrus Nematode (*Tylenchulus semipenetrans*)	Root knot nematode (*Meloidogyne* sp.)	Root lesion nematode (*Pratylenchus* sp.[1])	Pin nematode (*Criconemella xenoplax*[2])	Other
5BB Kober	99/00	0	0	0	0	0
	00/01	0	0	0	0	0
	01/02	0	0	0	0	0
Fercal	99/00	0	48	45	45	0
	00/01	0	0	0	0	0
	01/02	0	0	0	0	0
1103 Paulsen	99/00	0	0	0	0	0
	00/01	0	0	0	0	0
	01/02	0	50	50	0	0
140-Ruggeri	99/00	0	0	0	0	0
	00/01	42	0	42	0	0
	01/02	0	0	0	0	0
Ramsey	99/00	0	0	0	39	0
	00/01	0	0	0	0	0
	01/02	0	0	0	0	0
101-14	99/00	0	0	0	0	0
	00/01	0	0	0	0	0
	01/02	0	0	0	0	0
Teleki 5C	99/00	0	0	0	0	43 *Scutellonema*[3]
	00/01	0	0	0	47	0
	01/02	0	0	49	0	0

[1.] *Pratylenchus* were not identified to species level and different species have different levels of pathogenicity on grapevines. They would most likely be *Pratylenchus vulnus*, *P. scribneri* or *P. coffeae* as these are the most common species identified in the Sunraysia region (Max Sauer).
[2.] *Criconemella xenoplax* are often found associated with grapevines or the weeds growing around grapevines but no pathogenicity tests have been done on these species and thus nothing is known of their effect on grapevine yield.
[3.] *Scutelonema* sp. Are commonly found associated with grasses. Their effect on grapevines is not known but would be expected to be insignificant.

Nematode counts at the Gol Gol Shiraz site were generally higher than those observed at the Robinvale Chardonnay and Cabernet Sauvignon sites. The number of nematodes observed during the 2001/02 season was low compared to previous seasons where monitoring was conducted. None of the soil samples for 2001/02 contained any Citrus nematodes (*Tylenchulus semipenetrans*). This was surprising because high citrus nematode counts were previously observed in Shiraz grafted to 5BB Kober, 1103 Paulsen and 101-14. No Root knot nematodes (*Meloidogyne* sp.) were observed in the Shiraz site during the 2001/02 season. In the Shiraz site, Root lesion nematodes (*Pratylenchus* sp.) were found in all rootstocks except 5C Teleki and Pin nematodes (*Criconemella xenoplax*) were only observed in soil samples collected from 1103 Paulsen, 101-14 and 5C Teleki vines during the 2001/02 season.

No nematodes were observed in any of the soil samples collected from the Chardonnay site at Robinvale during the 2001/02 season. This result is not surprising considering that only low nematode counts have been observed in previous seasons.

Analysis of nematode data at the Cabernet Sauvignon site, located near Robinvale, during the 2001/02 season revealed a low number of Root knot nematodes only in soil samples collected from 1103 Paulsen vines. Root lesion nematodes were only observed in 5C Teleki, again only in low numbers. No Pin nematodes or other species of nematodes were observed during the 2001/02 season.

There appeared to be a large variation in the nematode numbers between the two experimental sites (1-Shiraz at Gol Gol and 2-Chardonnay and Cabernet Sauvignon at Robinvale). Only two replicates per rootstock/scion combination were sampled each year, therefore results need to be interpreted with a degree

of caution. Nothing is known about the susceptibility of 5BB Kober, 5C Teleki and 1103 Paulsen to Root lesion nematodes. Trials have shown that Ramsey is highly susceptible and 101-14 is moderately affected by Root lesion nematodes.

4.3 Pruning Weight Assessments

For the Shiraz site in 2000, Ramsey recorded the highest pruning weights and was significantly different to all other rootstocks except 116-60 Lider (Figure 1). However, 116-60 Lider was not significantly different to 101-14 or 1103 Paulsen (Figure 1). The lowest pruning weights were recorded in 5C Teleki and 5BB which were not significantly different to 101-14 or 1103 Paulsen (Figure 1).

For the Chardonnay site in 2001, 101-14 and Ramsey recorded the highest pruning weights and were significantly different to all the other rootstocks (Figure 2).

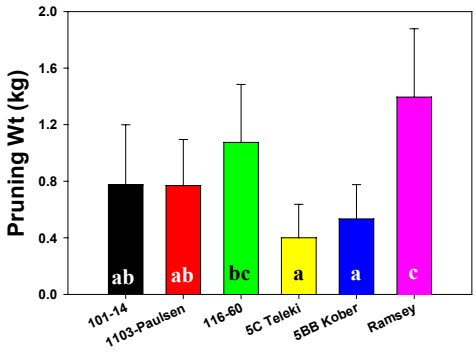


Figure 1. Pruning weights of Shiraz, August 2000

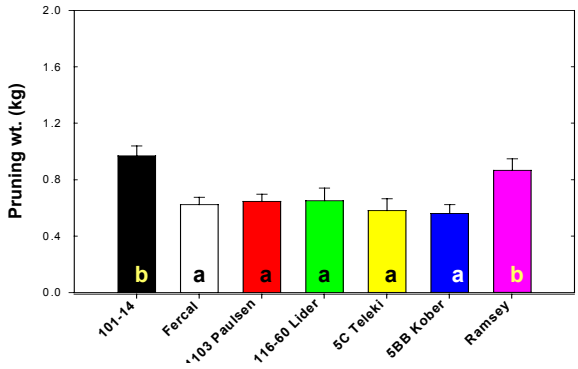


Figure 2. Pruning weights of Chardonnay, July 2001

4.4 Weather data

Analysis of long-term weather data indicated that Mildura and Robinvale have very similar climates (Figures 3 and 4 respectively). Robinvale does tend to have slightly wetter January, February and March periods. However, temperature conditions are very similar at both locations.

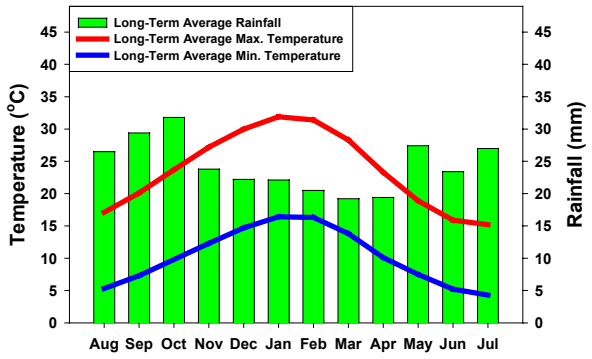


Figure 3 - Mildura Long-Term Weather Data

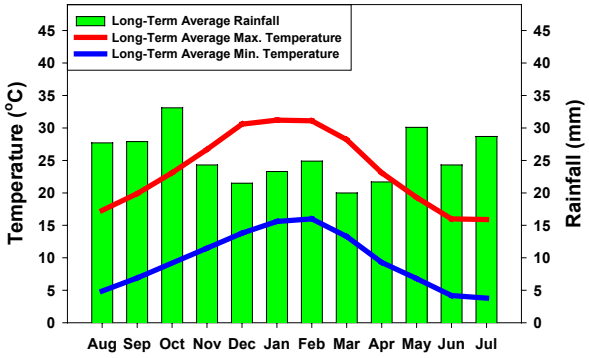


Figure 4 - Robinvale Long-Term Weather Data

Analysis of the 1999/2000 weather data revealed that above average rainfalls occurred in both November and February (Figure 5). The temperature conditions were also below normal during the November – December period and warmer during February (Figure 5). This indicates that the 1999/2000 growing season was rather atypical when compared to the long-term average data.

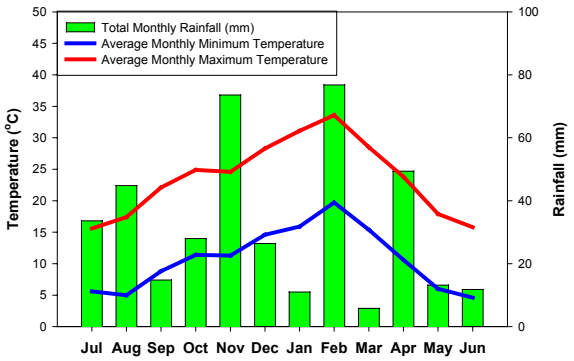


Figure 5 - Mildura Weather Data 1999/2000

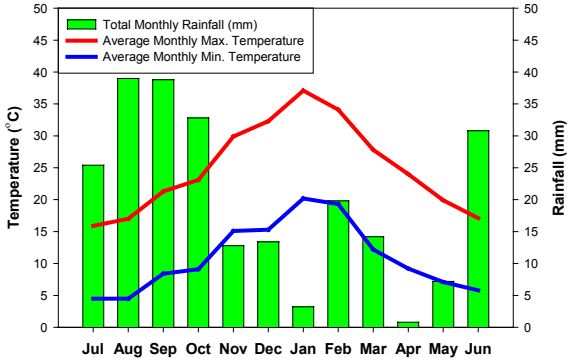


Figure 6 - Mildura Weather Data 2000/2001

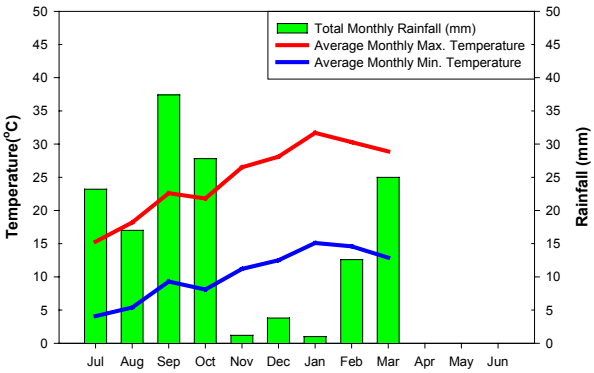


Figure 7 - Mildura Weather Data 2001/2002

Analysis of 2000/2001 weather data revealed August, September and October were very wet months when compared to the district average (Figure 6). January and February were dry and very warm with January having a record high mean maximum monthly temperature of 37.1°C (Figure 6).

Analysis of 2001-2002 weather data indicated November, December and January were very dry months when compared to Mildura Long-Term Weather data (Figure 7). September had a higher total monthly rainfall than average (Figure 7). Also, the 2001/02 season was generally cool, with below average mean monthly temperatures observed between October – March.

4.5 Maturity Testing and Berry Weights

4.5.1 Shiraz

In 2002, 101-14 generally ripened earlier than all other rootstocks (Figure 8). 1103 Paulsen, 5BB Kober and 5C Teleki were approximately 1 week later ripening compared to 101-14 (figure 8). Both 116-60 Lider and Ramsey were late ripening compared to all other rootstocks. These two rootstocks would have reached 24 °Brix approximately 3 weeks after 101-14 (Figure 8).

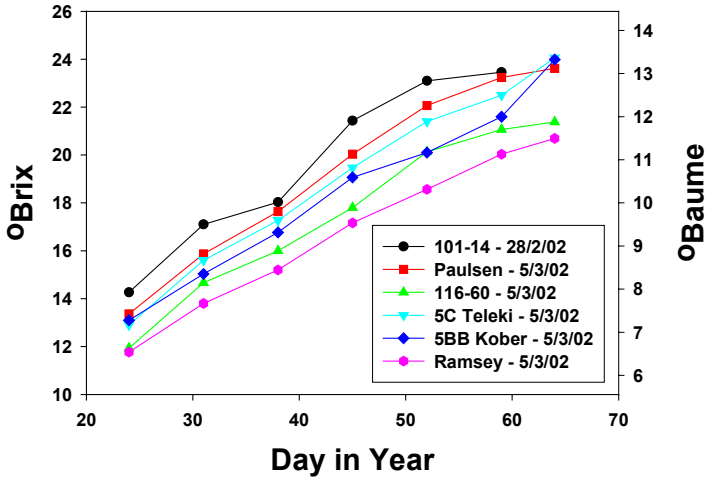


Figure 8. The average maturity (°Brix/Baume) of Shiraz grafted to six different rootstocks from post-veraison to harvest during the 2001/02 season. Harvest date indicated in graph legend.

In 2001/02 as the berries ripened, the average berry weight increased until approximately day 45, after which average berry weight tended to decrease (Figure 9). While this shrivel phenomenon is typical of Shiraz, large differences were observed between different rootstocks. Ramsey exhibited the largest reduction in berry weight after day 45, whereas in 1103 Paulsen no berry shrivel was observed after day 45 (Figure 9).

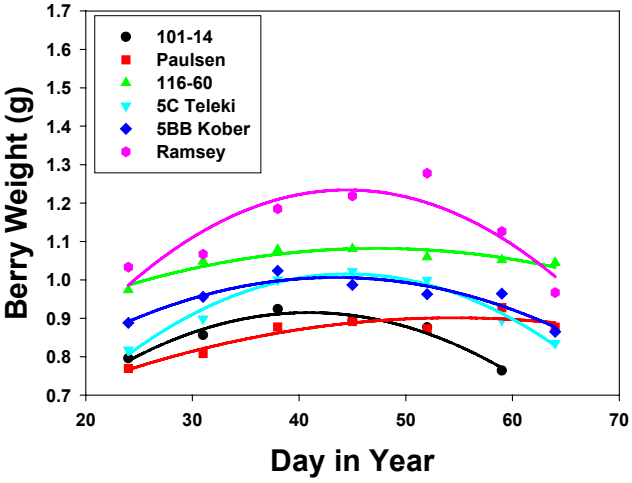


Figure 9. The average berry weight (g) of Shiraz grafted to six different rootstocks from post-veraison to harvest during the 2001/02 season.

4.5.2 Chardonnay

In 2001/02, 101-14, 1103 Paulsen, 116-60 Lider and 5C Teleki all ripened approximately one week earlier than 5BB Kober, Ramsey and Fercal (Figure 10). Because of the cooler season, harvest date for Chardonnay was generally delayed by approximately 2-3 weeks. Interestingly, between day 10 – 30, 101-14 was behind in ripening compared to most other rootstocks, however, by day 50 it had the highest °Brix (22.96) reading compared to all other rootstocks (Figure 10).

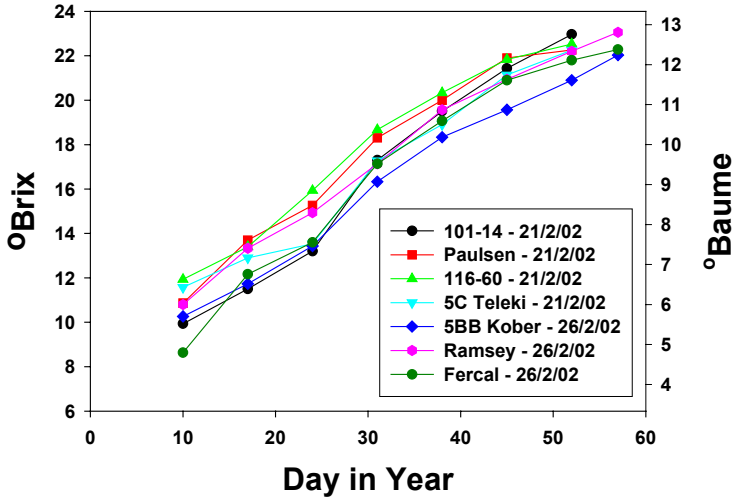


Figure 10. The average maturity (°Brix/Baume) of Chardonnay grafted to seven different rootstocks from post veraison to harvest during the 2001/02 season. Harvest date indicated in graph legend.

In 2001/02, the average berry weight of all roostocks grafted to Chardonnay increased at a similar rate until approximately day 40. After day 40, only minor changes in the average berry weight were observed (Figure 11). Ramsey and Fercal had the highest average berry weight at harvest (0.97 and 0.99g respectively) (Figure 11). 5C Teleki had the lowest average berry weight at harvest (0.81g) (Figure 11).

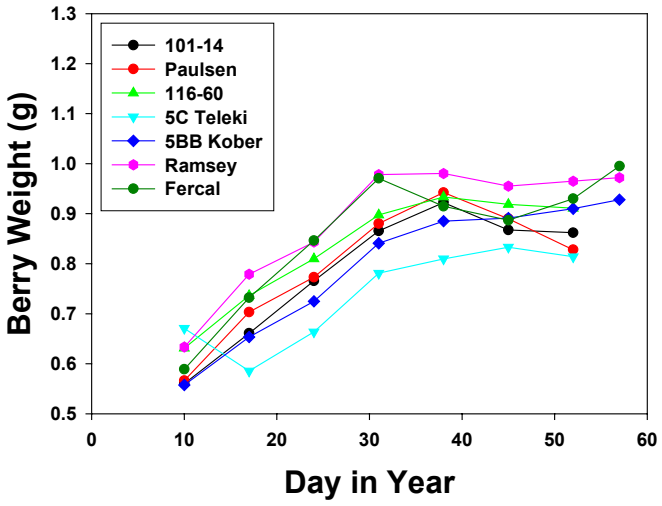


Figure 11. The average berry weight (g) of Chardonnay grafted to seven different rootstocks from post-veraison to harvest during the 2001/02 season.

4.5.3 Cabernet Sauvignon

In 2001/02, 101-14 and 5C Teleki ripened approximately 5 days to a week ahead of all of the other remaining rootstocks (Figure 12). Generally, most of the rootstocks tended to ripen at a fairly similar rate between day 24 and day 72 (Figure 12).

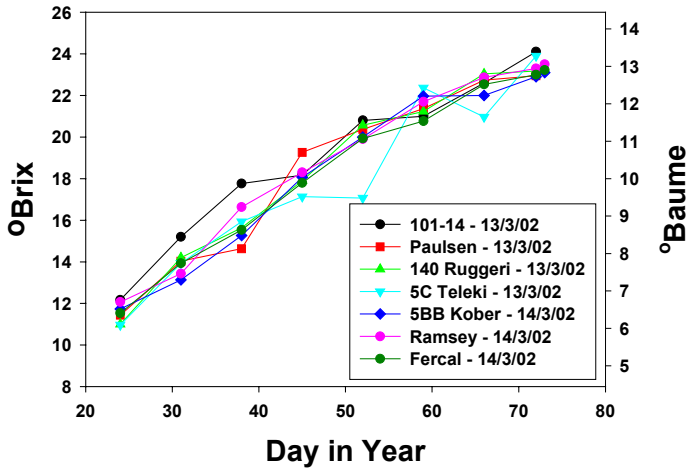


Figure 12. The average maturity (°Brix/Baume) of Cabernet Sauvignon grafted to seven different rootstocks from post-veraison to harvest during the 2001/02 season. Harvest date indicated in graph legend.

In Cabernet Sauvignon during the 2001/02 season, there was only minor changes in average berry weight of each individual rootstock between days 24 and 72 (Figure 13). However, large differences were observed in the average berry weight of different rootstocks, where Ramsey and Fercal generally had the largest average berry weights and 140 Ruggeri, 5BB Kober and 5C Teleki generally had the lowest average berry weights (Figure 13).

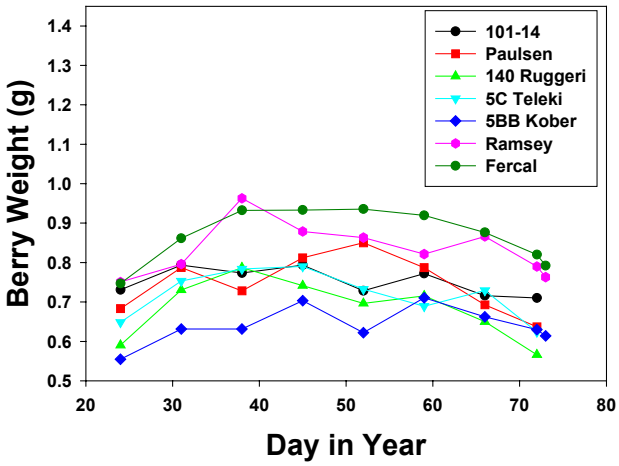


Figure 13. The average berry weight (g) of Cabernet Sauvignon grafted to seven different rootstocks from post-veraison to harvest during the 2001/02 season.

4.6 Harvest Assessment

The results from each analysis are presented graphically with standard error bars for each treatment. Average data is presented from each of the years where rootstock evaluation has been conducted (i.e. 1999/2000, 2000/01 and 2001/02). For ease of interpretation, statistical significance (p<0.05) between treatments is not shown on this graphed data because of the potential for confusion. Results of the statistical

analysis will be discussed in the text, but please refer to Tables 1 (Shiraz), 2 (Chardonnay) and 3 (Cabernet Sauvignon) in the appendices of this report for a summary of all statistical analysis.

4.6.1 Shiraz

(a) Yield (kg/vine)

2000:

The highest average yield per vine was recorded in the Ramsey rootstock (14.4kg/vine, Figure 14). This was significantly (p=0.05) higher than the 101-14, 5C Teleki and 5BB Kober rootstocks which had yields per vine of 8.9, 6.8 and 6.3 kg/vine respectively. 1103 Paulsen and 116-60 Lider did have a significantly higher yield per vine than 5C Teleki and 5BB Kober. However, the yield was not significantly different to either Ramsey or 101-14 (Figure 14).

2001:

The highest average yield per vine was recorded in the Ramsey rootstock (19.38kg/vine, Figure 14). This was not significantly higher than 116-60 Lider (18.10kg/vine) or 1103 Paulsen (15.73kg/vine). 116-60 Lider and Ramsey were significantly (p=0.001) higher than the 101-14, 5BB Kober and 5C Teleki rootstocks which had yields of 12.08, 11.79 and 10.42 kg/vine respectively (Figure 14).

2002:

The highest average yield per vine was recorded in Ramsey and 116-60 Lider rootstocks (23.56 and 21.30kg/vine respectively, Figure 14). Ramsey and 116-60 Lider were significantly higher yielding than all other remaining rootstocks (Figure 14).

3 Year Summary:

Ramsey/116-60 Lider > 101-14/1103 Paulsen > 5C Teleki/5BB Kober

(b) Bunch number per vine

2000:

5BB Kober had a significantly lower average total bunch number per vine (112 bunches/vine) compared to both 116-60 Lider and Ramsey, which had 161 and 166 bunches per vine respectively (Figure 15). 101-14, 1103 Paulsen and 5C Teleki did not differ significantly to any rootstocks with respect to bunch number per vine (Figure 15).

2001:

No significant differences were observed in average bunch number per vine between all of the different rootstocks (Figure 15).

2002:

Both 101-14 and Ramsey had the highest number of bunches per vine (232 and 223 bunches per vine respectively, Figure 15). This was significantly higher than 1103 Paulsen, 116-60 Lider and 5C Teleki which had 176, 184 and 165 bunches per vine respectively. No significant difference was observed in 5BB Kober compared to all other rootstocks (Figure 15).

3 Year Summary:

Varied significantly over the 3 year evaluation period.

But Ramsey/116-60 Lider > 101-14/1103 Paulsen > 5C Teleki/5BB Kober

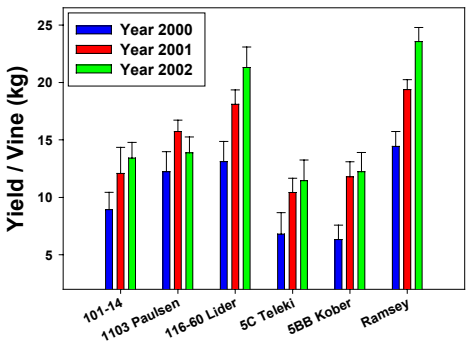


Figure 14.

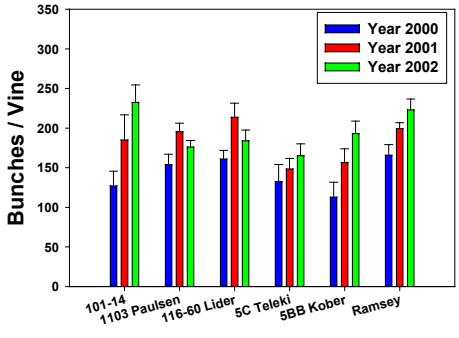


Figure 15.

(c) Average bunch weight (g)

2000:

5C Teleki and 5BB Kober had a significantly lower average bunch weight (47.26 and 53.29g/bunch respectively) compared to 1103 Paulsen, 116-60 Lider and Ramsey which had average bunch weights of 79.87, 82.72 and 87.03g/bunch respectively (Figure 16). The average bunch weight of 101-14 did not differ significantly from any of the other rootstocks (Figure 16).

2001:

Ramsey recorded the highest bunch weight (97.19g/bunch, Figure 16). This was significantly higher than all other rootstocks. The second highest bunch weight was recorded in 116-60 Lider (84.74g). This was significantly higher than both 101-14 and 5C Teleki (65.30g and 70.15g respectively). 1103 Paulsen and 5BB Kober had average bunch weights of 80.44g and 75.29g respectively.

2002:

116-60 Lider and Ramsey had the highest average bunch weight (115.76g and 105.65g respectively, Figure 16). These were significantly higher than all of the other remaining rootstocks (Figure 16).

3 Year Summary:

Ramsey/116-60 Lider > 1103 Paulsen > 5C Teleki/5BB Kober/101-14

(d) Average berry weight (g)

2000:

5BB Kober had a significantly lower average berry weight (0.72g/berry) compared to any of the other rootstocks (Figure 17). The nearest to the 5BB Kober was the 1103 Paulsen with 0.92g/berry (Figure 17). The largest average berry weights were observed in 101-14, however, this did not differ significantly to 1103 Paulsen, 116-60 Lider, 5C Teleki and Ramsey (Figure 17).

2001:

No rootstocks differed significantly with respect to average berry weight (Figure 17).

2002:

116-60 Lider had the highest average berry weight (1.05g). This was significantly higher than 101-14 and 5C Teleki (0.76 and 0.83g respectively, Figure 17). 1103 Paulsen, 5BB Kober and Ramsey all had average berry weights of 0.88, 0.87 and 0.97g respectively.

3 Year Summary:

Varied significantly over the 3 year evaluation period. Slightly higher berry weights in 116-60 Lider and Ramsey.

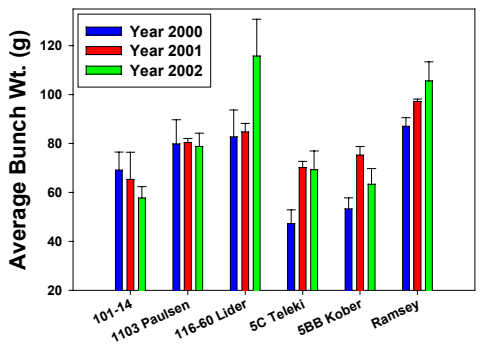


Figure 16.

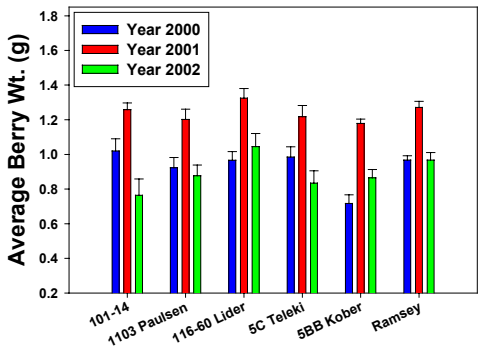


Figure 17.

(e) ^{o}Brix/^{o}Baume

Although the aim was to harvest all Shiraz rootstocks at 13.5 Baume (24.3^{o}Brix), some significant differences are observed in the maturity of grapes at harvest.

2000:

101-14 and 5BB Kober did have a significantly higher Baume/^{o}Brix compared to 1103 Paulsen (Figure 18). The remaining rootstocks (116-60 Lider, 5C Teleki and Ramsey) did not differ significantly from any other rootstocks (Figure 18). The 101-14 rootstock was harvested on the 15/2/00, almost 6 weeks earlier than either the 5BB Kober or Ramsey, which was harvested on the 27/3/00 (Figure 18).

2001:
101-14 did have a significantly higher Baume/°Brix compared to all other rootstocks (Figure 18). Ramsey had the second highest Baume and was significantly higher than all remaining rootstocks (1103 Paulsen, 116-60 Lider, 5C Teleki and 5BB Kober) which did not differ significantly from each other (Figure 18).
2002:
Ramsey and 116-60 Lider were harvested at a significantly lower Baume/°Brix (20.7 and 21.4 °Brix respectively) compared to all other remaining rootstocks (Figure 18).
3 Year Summary:
101-14 > 5BB Kober > 1103 Paulsen/116-60 Lider/5C Teleki > Ramsey

(f) pH
2000:
The highest average pH was observed in Ramsey (3.94), which was significantly higher than 101-14 (3.67) and 1103 Paulsen (3.57). There was no significant difference between 116-60 Lider (3.82), 5BB Kober (3.79), 5C Teleki (3.73), 101-14 (3.67) and 1103 Paulsen (3.57, Figure 19).
2001:
The lowest average juice pH was observed in 5BB Kober (3.91), which was significantly lower than all other rootstocks (Figure 19). Ramsey had the highest juice pH of 4.98 (Figure 19). This was significantly higher than all other rootstocks.1103 Paulsen and 5C Teleki had pH values of 4.51 and 4.56 respectively and were significantly different to 101-14 and 116-60 Lider which both had pH values of 4.10 (Figure 19).
2002:
101-14 and 5BB Kober had significantly lower juice pH's (3.63 and 3.67 respectively) compared to all other remaining rootstocks (Figure 19).
3 Year Summary:
Ramsey/116-60 Lider > 101-14/1103 Paulsen/5C Teleki/5BB Kober

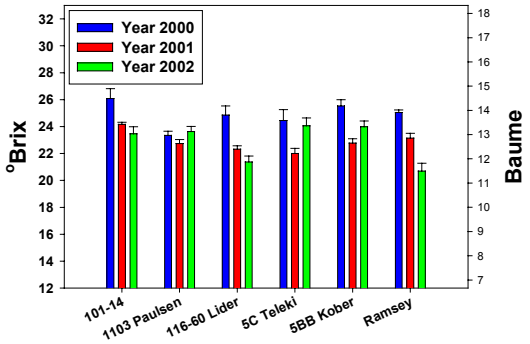


Figure 18.

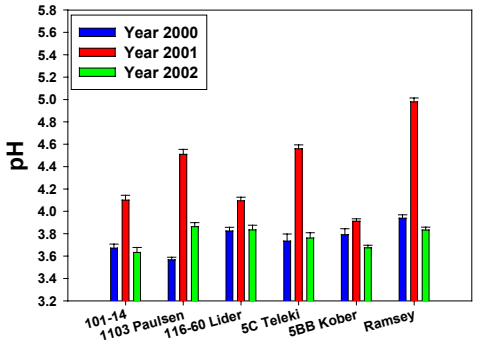


Figure 19.

(g) Titratable Acidity (g/L)
2000:
101-14 and 1103 Paulsen had a significantly higher titratable acidity (5.31 and 5.16 g/L tartaric acid equivalents respectively) compared to all other rootstocks (Figure 20). Differences in juice pH and titratable acidity may be attributed to differences in harvest dates.
2001:
116-60 Lider had the highest titratable acidity (3.93 g/L tartaric acid equivalents) compared to all other rootstocks, except for 5BB Kober which had a titratable acidity of 3.71g/L (Figure 20). 5C Teleki had the lowest titratable acidity (2.98g/L) however, this was not significantly different from 1103 Paulsen and Ramsey which had 3.05 and 3.08 4g/L respectively (Figure 20).
2002:
No significant differences observed in average titratable acidity (g/L) between all of the different rootstocks (Figure 20).
3 Year Summary:
Varied significantly over the 3 year evaluation period. Levels were also dependant on rate of ripening.
But, 101-14/1103 Paulsen/5BB Kober > 116-60 Lider/5C Teleki/Ramsey

(h) Juice Potassium (mM)

2000:

Ramsey had a significantly higher concentration of potassium in the juice (70.4mM) compared to both 1103 Paulsen and 5BB Kober, which had concentrations of 56.8 and 56.1mM respectively (Figure 21). 101-14, 116-60 Lider and 5C Teleki did not differ significantly from all other rootstocks (Figure 21).

2001:

101-14 had a significantly higher concentration of potassium in the juice (57.6mM) compared to both 5C Teleki and 5BB Kober, which had concentrations of 46.8 and 43.1mM respectively (Figure 21). 1103 Paulsen, 116-60 Lider and Ramsey did not differ significantly from all other rootstocks (Figure 21).

2002:

The lowest juice potassium concentration was observed in 101-14 (34.3 mM). This was significantly lower than all other rootstocks (Figure 21). Ramsey had the highest concentration of juice potassium with 57.4mM, which was significantly higher than 5C Teleki and 5BB Kober which had concentrations of 47.6 and 48.2mM respectively (Figure 21).

3 Year Summary:

Ramsey/116-60 Lider/1103 Paulsen > 101-14/5C Teleki/5BB Kober

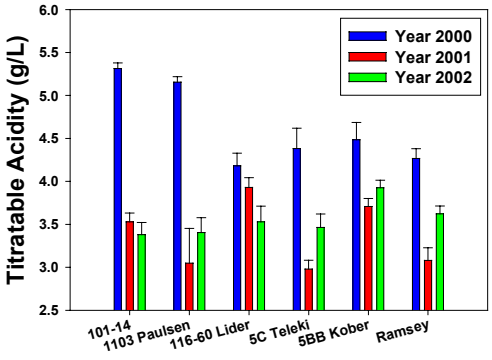


Figure 20.

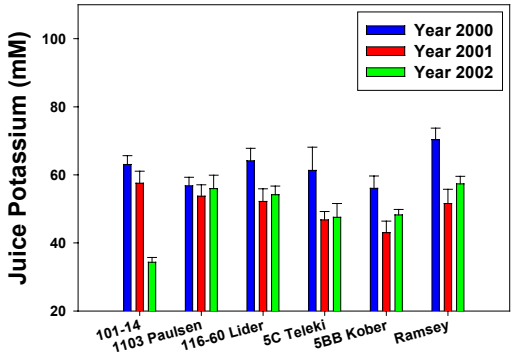


Figure 21.

(i) Juice Sodium (mM)

2000:

Ramsey had the highest average concentration of sodium in the juice (4.6mM), which was significantly higher than all other rootstocks, except 116-60 Lider, which had a concentration of 4.0mM (Figure 22). 101-14, 1103 Paulsen and 5BB Kober had the lowest average concentration of sodium in the juice (2.5, 2.4 and 2.5mM respectively), which did not differ significantly when compared to 5C Teleki, however was significant when compared to both 116-60 Lider and Ramsey (Figure 22).

2001:

Ramsey and 116-60 Lider had the highest average concentrations of sodium in the juice (2.18 and 1.94mM respectively), which was significantly higher than 101-14, 1103 Paulsen, 5C Teleki and 5BB Kober which had the lowest average concentration of sodium in the juice (1.48, 1.24, 1.39 and 1.01mM respectively). 101-14, 1103 Paulsen, 5C Teleki and 5BB Kober did not differ significantly when compared to each other (Figure 22).

2002:

No significant differences observed in average juice sodium concentration (mM) between all of the different rootstocks (Figure 22).

3 Year Summary:

Ramsey > 116-60 Lider > 1103 Paulsen/5C Teleki > 101-14/5BB Kober

(j) Juice Chloride (mM)

2000:

116-60 Lider had a significantly higher concentration of chloride in the juice (2.87mM) compared to all other rootstocks, except 5C Teleki, which had a juice concentration of 2.38mM (Figure 23). There was no significant difference between 1103 Paulsen (1.57mM), 101-14 (1.72mM), 5BB Kober (2.11mM), Ramsey (2.04mM) and 5C Teleki (Figure 23).

2001:
116-60 Lider had a significantly higher concentration of chloride in the juice (1.35mM) compared to all other rootstocks, except for Ramsey (Figure 23). Ramsey did not differ significantly from all other rootstocks (Figure 23).
2002:
116-60 Lider and 5C Teleki had significantly higher juice chloride concentrations (2.31 and 2.04mM) compared to all other rootstocks (Figure 23).
3 Year Summary:
116-60 Lider > 5C Teleki > Ramsey > 101-14/1103 Paulsen/5BB Kober

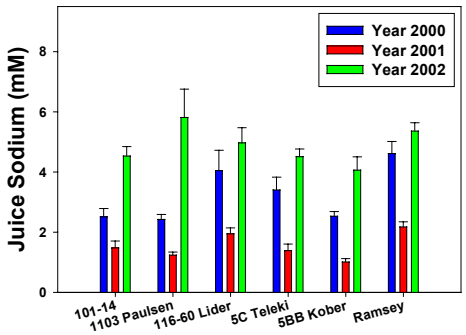


Figure 22.

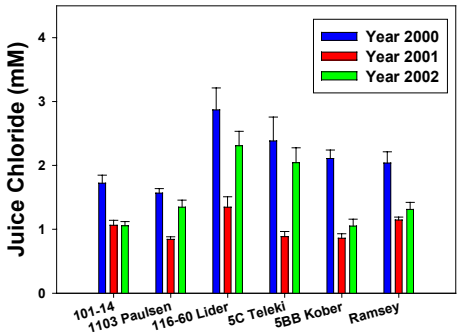


Figure 23.

(k) Juice Nitrogen (% Total)
2000:
101-14 and 1103 Paulsen had a significantly lower percent nitrogen in the juice (0.06 and 0.05% respectively) compared to all other rootstocks (Figure 24). Ramsey had the highest percentage of nitrogen in the juice (0.076%), which was significantly higher than all other rootstock, except for 5BB Kober, which had a concentration of 0.072% (Figure 24).
2001:
5BB Kober had a significantly lower percent nitrogen in the juice (0.05%) compared to all other rootstocks, except for 101-14 and 5C Teleki which had nitrogen percentages of 0.058 and 0.057 respectively (Figure 24). Ramsey had the highest percentage of nitrogen in the juice (0.67%), which was significantly higher than all other rootstocks, except for 1103 Paulsen and 116-60 Lider which had juice nitrogens of 0.059% and 0.061% respectively (Figure 24).
2002:
101-14 had the lowest percent nitrogen in the juice (0.031%), which was significantly lower than all other rootstocks which were evaluated (Figure 24). 1103 Paulsen and Ramsey had the highest percent nitrogen in the juice (0.056 and 0.053% respectively), which was significantly higher than 116-60 Lider, 5C Teleki and 5BB Kober (0.047, 0.044 and 0.046% respectively, Figure 24).
3 Year Summary:
Ramsey > 116-60 Lider/5C Teleki/5BB Kober > 101-14/1103 Paulsen

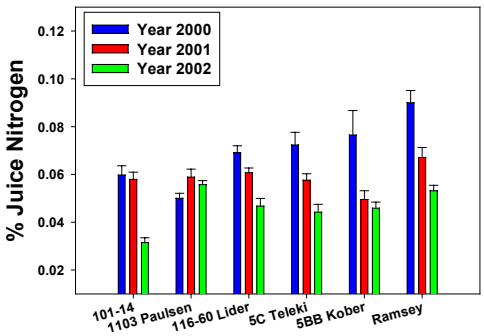


Figure 24.

(l) Colour (mg anthocyanin/g)

2000:

5BB Kober had a significantly higher concentration of anthocyanin in the fruit (1.54 mg/g) compared to all other rootstocks (Figure 25). 1103 Paulsen and 116-60 Lider had a significantly lower concentration of anthocyanin (1.02 and 0.88mg/g respectively) in the fruit compared to all other rootstocks (Figure 25). 101-14, 5C Teleki and Ramsey were middle of the range in concentration of anthocyanin in the fruit (Figure 25).

2001:

5BB Kober and 101-14 had significantly higher concentrations of colour in the fruit (1.06 and 0.94mg/g) compared to all other rootstocks, except for 5C Teleki which had colour levels of 0.86 mg/g (Figure 25). 5C Teleki did not differ significantly from any of the rootstocks (Figure 25).

2002:

101-14, 5C Teleki, 5BB Kober and 1103 Paulsen had significantly higher concentrations of anthocyanins in the fruit (1.38, 1.39, 1.30 and 1.18 mg/g respectively) compared to both 116-60 Lider and Ramsey which had concentrations of 0.95 and 0.74mg/g respectively (Figure 25).

3 Year Summary:

5 BB Kober > 101-14/5C Teleki > 1103 Paulsen > 116-60 Lider/Ramsey

(m) Total Phenolics (au/g)

2000:

5BB Kober had a significantly higher concentration of phenolics in the fruit (1.51au/g) compared to all other rootstocks (Figure 26). 1103 Paulsen and 116-60 Lider had a significantly lower concentration of phenolics (0.97 and 0.92au/g respectively) in the fruit compared to all other rootstocks (Figure 26). 101-14, 5C Teleki and Ramsey were middle of the range, in terms of phenolics in the fruit (Figure 26).

2001:

101-14 had a significantly higher concentration of phenolics in the fruit (1.02 au/g) compared to all other rootstocks except for 5C Teleki and 5BB Kober which had 0.93 and 0.99 au/g respectively (Figure 26). Ramsey had the lowest contentration of phenolics (0.74 au/g) compared to all other rooststocks except 1103 Paulsen and 116-60 Lider which had phenolic concentrations of 0.84 and 0.85 au/g respectively (Figure 26).

2002:

101-14, 1103 Paulsen, 5C Teleki and 5BB Kober had significantly higher concentrations of total phenolics in the fruit (1.45, 1.27, 1.32 and 1.29au/g respectively) compared to both 116-60 Lider and Ramsey (1.17 and 1.03au/g respectively).

3 Year Summary:

101-14/5BB Kober > 5C Teleki >1103 Paulsen/116-60 Lider/Ramsey

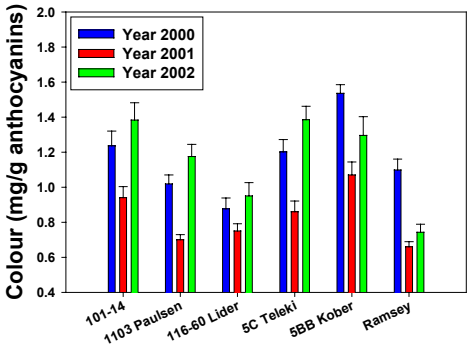


Figure 25.

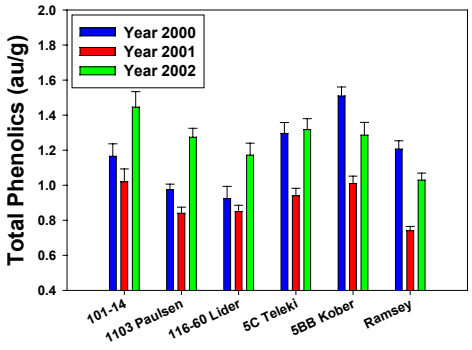


Figure 26.

4.6.2 Chardonnay

(a) Yield (kg/vine)

2000:

5C Teleki and Ramsey had a significantly higher average yield per vine (19.4 and 18.6kg/vine respectively) compared to 1103 Paulsen, which had 15.7kg/vine (Figure 27). 101-14, 116-60 Lider, 5BB Kober and Fercal did not differ significantly from any other rootstocks (Figure 27).

2001:

No rootstocks differed significantly from each other with respect to yield per vine (Figure 27).

2002:

No rootstocks differed significantly from each other with respect to yield per vine (Figure 27).

3 Year Summary:

101-14/116-60 Lider/Ramsey/Fercal > 1103 Paulsen/5C Teleki/5BB Kober

(b) Bunch number per vine

2000:

101-14 had a significantly higher average bunch number per vine (202 bunches/vine) compared to both 1103 Paulsen and 5BB Kober, which had 156 and 157 bunches per vine respectively (Figure 28). 116-60 Lider, 5C Teleki, Ramsey and Fercal did not differ significantly from any other rootstocks (Figure 28).

2001:

116-60 Lider, 101-14, 5BB Kober and 5C Teleki had a significantly higher average bunch number per vine (294, 290.5, 263.2 and 242.4 bunches per vine respectively) compared with Fercal which had the lowest average bunch number with 178.4 bunches per vine (Figure 28). 1103 Paulsen and 5C Teleki did not differ significantly in bunch number per vine from any other rootstocks (Figure 28).

2002:

No rootstocks differed significantly from each other with respect to bunch number per vine (Figure 28).

3 Year Summary:

101-14/116-60 Lider/Ramsey > 1103 Paulsen/5C Teleki/5BB Kober/Fercal

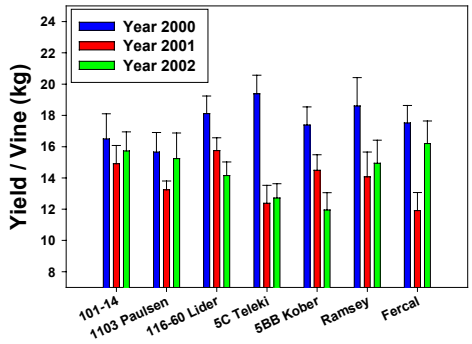


Figure 27.

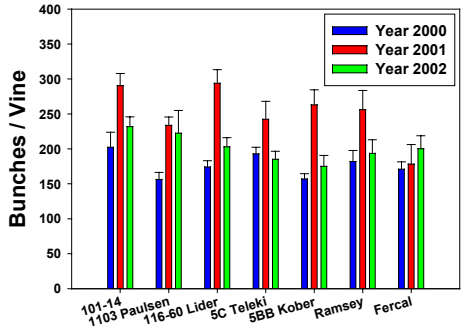


Figure 28.

(c) Bunch weight (g)

2000:

101-14 had a significantly lower average bunch weight (82.7g) compared to all other rootstocks (Figure 29). 1103 Paulsen, 116-60 Lider, 5C Teleki, 5BB Kober, Ramsey and Fercal had average bunch weights of 99.3, 103.7, 100.4, 111.4, 105.2 and 103.7g respectively (Figure 29).

2001:

Fercal had a significantly higher average bunch weight (66.77g) compared to all other rootstocks (Figure 29). 101-14, 1103 Paulsen, 116-60 Lider, 5C Teleki, 5BB Kober and Ramsey had average bunch weights of 51.31, 56.65, 53.56, 51.07, 55.03 and 54.93g respectively (Figure 29). There was no significant difference in bunch weight between these different rootstocks (Figure 29).

2002:

Fercal had a significantly higher average bunch weight (80.9) compared to all other rootstocks except Ramsey (77.2g, Figure 29). 101-14 had the lowest average bunch weight (67.8g), but this was not

significantly lower than 1103 Paulsen, 116-60 Lider, 5C Teleki and 5BB Kober which had bunch weights of 68.5, 69.7, 68.7 and 68.2g respectively (Figure 29).

3 Year Summary:

Fercal/Ramsey/5BB Kober > 1103 Paulsen/116-60 Lider/5C Teleki > 101-14

(d) Berry weight (g)

2000:

There was no significant difference in the average berry weight of all rootstocks (Figure 30). The average berry weight in this rootstock trial ranged between 0.93 and 0.99g (Figure 30).

2001:

1103 Paulsen had a significantly lower average berry weight (0.69g) than all other rootstocks (Figure 30). 101-14, 116-60 Lider and Fercal all had significantly higher average berry weights (0.80, 0.82 and 0.81g respectively) than all other roostocks, except for Ramsey which had an average bunch weight of 0.77g (Figure 30). The remaining rootstocks (5C Teleki and 5BB Kober) had average berry weights of 0.74 and 0.73g respectively and did not differ significantly from each other (Figure 30).

2002:

Fercal, Ramsey and 5BB Kober had significantly higher average berry weights (0.99, 0.97 and 0.93g respectively) compared to all other rootstocks, except 116-60 Lider which had an average berry weight of 0.91g (Figure 30). 5BB Kober was not significantly different to 116-60 Lider, 1103 Paulsen and 101-14 (Figure 30).

3 Year Summary:

Fercal/Ramsey/116-60 Lider > 101-14/5C Teleki/5BB Kober > 1103 Paulsen

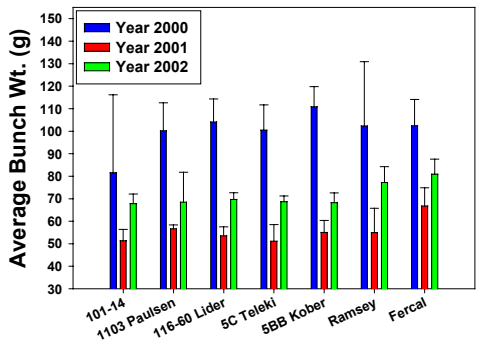


Figure 29.

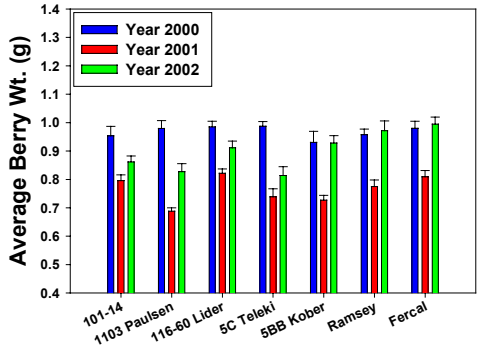


Figure 30.

(e) ^{o}Brix/^{o}Baume

The aim was to harvest all rootstocks on Chardonnay at 13.0 Baume (23.4°Brix). However, some significant differences were observed in maturity.

2000:

101-14 did have a significantly higher Baume/°Brix at harvest (13.1 Baume) compared to 116-60 Lider, 5BB Kober, Ramsey and Fercal, which had Baumes of 12.6, 12.6, 12.5 and 12.4 respectively (Figure 31). The remaining rootstocks (1103 Paulsen and 5C Teleki) did not differ significantly from any rootstock (Figure 31). The 101-14 was harvested on the 9/2/00, one week earlier than either the 5BB Kober or Ramsey, which was harvested on the 16/2/00 (Figure 31).

2001:

There were no significant differences observed in the harvest Baume/°Brix of the rootstocks this year (Figure 31).

2002:

There were no significant differences observed in the harvest Baume/°Brix of the rootstocks this year (Figure 31).

3 Year Summary:

101-14 > 1103 Paulsen/116-60 Lider/5C Teleki/5BB Kober/Ramsey/Fercal

(f) pH

2000:

The lowest average juice pH was observed in Fercal (3.50), which was significantly lower than any other rootstock (Figure 32). The remaining rootstocks did not differ significantly from each other (Figure 32).

2001:

The lowest average juice pH was observed in 101-14 (3.83), which was significantly lower than any other rootstock (Figure 32). 1103 Paulsen and 116-60 Lider did have a significantly lower pH (3.98 and 3.97 respectively) than 5C Teleki, 5BB Kober, Ramsey and Fercal (4.28, 4.22, 4.04 and 4.23 respectively). Ramsey differed significantly from all other rootstocks with a pH of 4.04 (Figure 32).

2002:

1103 Paulsen had a significantly lower juice pH (3.56) compared to 5BB Kober and Ramsey which had juice pH's of 3.65 and 3.69 respectively (Figure 32). The average pH of 101-14 and 116-60 Lider did not differ significantly to any other rootstock (Figure 32).

3 Year Summary:

5C Teleki/5BB Kober/Ramsey/Fercal > 101-14/1103 Paulsen/116-60 Lider

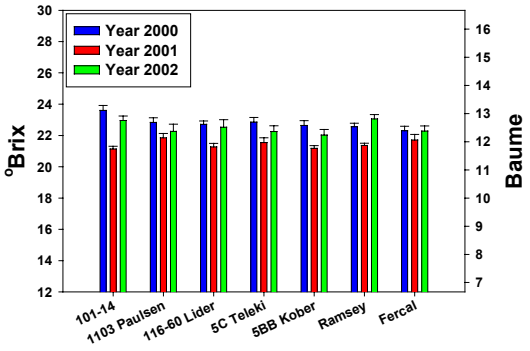


Figure 31.

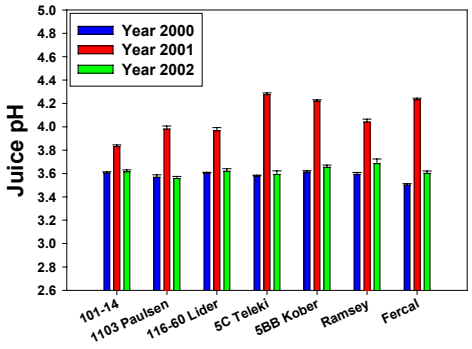


Figure 32.

(g) Titratable Acidity (g/L)

2000:

5C Teleki and Fercal had a significantly higher titratable acidity (5.54 and 5.48g/L tartaric acid equivalents respectively) compared to all other rootstocks (Figure 33). 5BB Kober (4.95g/L) had a significantly lower titratable acidity compared to any other rootstock (Figure 33). 101-14, 1103 Paulsen, 116-60 Lider and Ramsey were all middle of the range with titratable acidities of 5.31, 5.22, 5.23 and 5.28 g/L respectively (Figure 33).

2001:

101-14 had a significantly higher titratable acidity (4.56g/L tartaric acid equivalents) compared to all other rootstocks (Figure 33). 1103 Paulsen and Ramsey were middle of the range with titratable acidities of 3.73 and 3.71 g/L respectively, which were significantly lower than 116-60 Lider (3.97) and significantly higher than Fercal which had a pH value of 3.41 (Figure 33). 5BB Kober and 5C Teleki had the lowest titratable acidity with 3.12 and 3.28g/L respectively (Figure 33).

2002:

116-60 Lider had a titratable acidity (4.65g/L) which was significantly higher than 5BB Kober, Ramsey and Fercal (3.82, 3.99 and 4.18g/L respectively, Figure 33). 101-14, 1103 Paulsen and 5C Teleki all had mid-range average titratable acidity values (4.47, 4.44 and 4.39g/L respectively, Figure 33).

3 Year Summary:

101-14/116-60 Lider > 1103 Paulsen/5C Teleki/Ramsey/Fercal > 5BB Kober

(h) Juice Potassium (mM)

2000:

116-60 Lider had a significantly higher concentration of potassium in the juice (56.6mM) compared to both 101-14 and Fercal, which had concentrations of 52.8 and 52.4mM respectively (Figure 34). 1103 Paulsen, 5C Teleki, 5BB Kober and Ramsey did not differ significantly from any of the rootstocks (Figure 34).

2001:

5C Teleki and Fercal had a significantly higher concentration of potassium in the juice (68 and 63.3mM respectively) compared to all other rootstocks (Figure 34). 101-14, 1103 Paulsen, 116-60 Lider, 5BB Kober and Ramsey had potassium concentrations of 54.85, 57.57, 55.85, 57.00 and 58.08mM respectively (Figure 34).

2002:

101-14 and 116-60 Lider had a significantly higher average juice potassium concentration (49.4 and 48.4mM respectively) compared to 1103 Paulsen and 5BB Kober (42.8 and 44.2mM respectively, Figure 34). The average juice potassium concentration of Fercal did not differ significantly from any other rootstock (Figure 34).

3 Year Summary:

5C Teleki > 101-14/1103 Paulsen/116-60 Lider/5BB Kober/Ramsey/Fercal

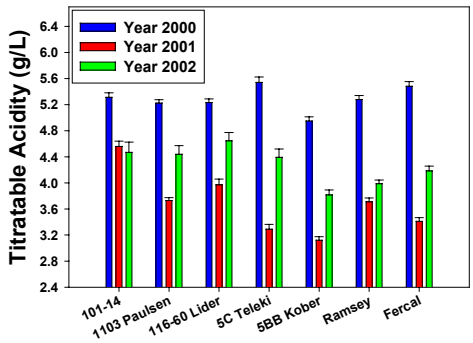


Figure 33.

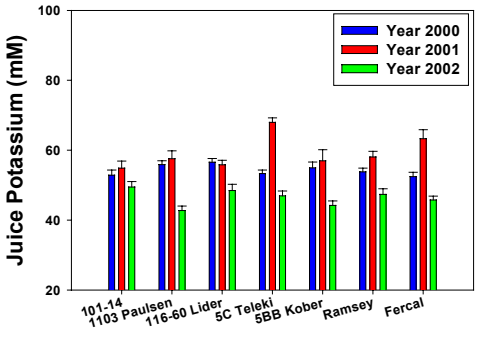


Figure 34.

(i) Juice Sodium (mM)

2000:

1103 Paulsen and 5C Teleki had the lowest average concentration of sodium in the juice (both were 1.26mM), which was significantly lower than all other rootstocks, except for Fercal. However, Fercal did not differ significantly from any of the other rootstocks (Figure 35).

2001:

116-60 Lider had the highest concentration of sodium in the juice (1.18mM). This was significantly higher than all other rootstocks, except for 101-14, 5C Teleki and Ramsey which had juice sodium concentrations of 0.95, 0.98 and 0.99 mM respectively (Figure 35). 5BB Kober had the lowest average concentration of sodium in the juice (0.73mM), but was not significantly lower than both 1103 Paulsen and Fercal which had juice sodium concentrations of 0.87 and 0.79mM respectively (Figure 35).

2002:

116-60 Lider, 5C Teleki and Ramsey had significantly higher juice sodium concenrations (3.79, 3.58 and 3.36mM respectively) compared to all remaining rootstocks (Figure 35).

3 Year Summary:

116-60 Lider > 5C Teleki/Ramsey > 101-14 > 1103 Paulsen/5BB Kober/Fercal

(j) Juice Chloride (mM)

2000:

116-60 Lider had a significantly higher concentration of chloride in the juice (0.94mM) compared to all other rootstocks (Figure 36). In the remaining rootstocks, 101-14 did have a significantly higher concentration of chloride (0.72mM) compared to 1103 Paulsen, which had a concentration of 0.62mM (Figure 36).

2001:

101-14 had a significantly lower concentration of chloride in the juice (0.40mM) compared to all other rootstocks (Figure 36). In the remaining rootstocks, 1103 Paulsen, 5C Teleki, 5BB Kober, and Fercal had a significantly higher concentration of chloride (0.88, 1.01, 0.93 and 0.89 respectively) compared to 116-60

Lider, which had a concentration of 0.65mM (Figure 36). Ramsey was only significantly higher than 101-14 with a juice chloride concentration of 0.77mM (Figure 36).

2002:

116-60 Lider had a significantly higher juice chloride concentration (0.84mM) compared to all other rootstocks (Figure 36). Fercal had the lowest juice chloride concentration (0.41mM), which was significantly lower than all remaining rootstocks except for 5BB Kober (0.45mM). All remaining rootstocks had intermediate concentrations of juice sodium (Figure 36).

3 Year Summary:

116-60 Lider/5C Teleki > 1103 Paulsen/5BB Kober/Ramsey/Fercal > 101-14

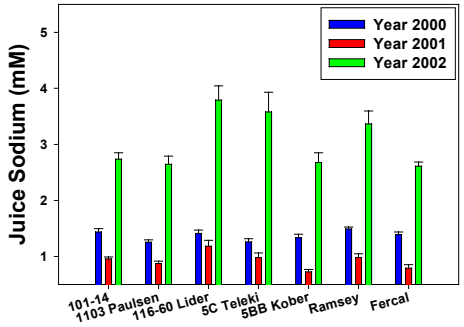


Figure 35.

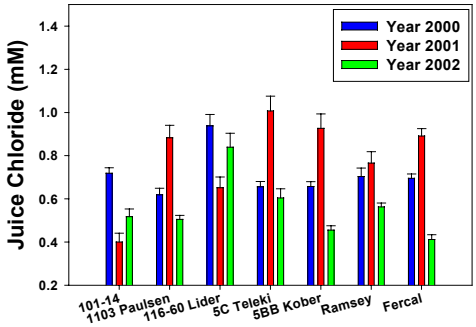


Figure 36.

(k) Juice Nitrogen (% Total)

2000:

Ramsey had a significantly higher percent nitrogen in the juice (0.089%) compared to all other rootstocks (Figure 37). The next highest was 5C Teleki and 5BB Kober (0.079 and 0.080% respectively), which were significantly higher than all other rootstocks, except for Ramsey. The lowest average percent nitrogen was recorded in Fercal (0.062%), which was significantly lower than all other rootstocks except for 1103 Paulsen and 116-60 Lider, which both had contents of 0.066% (Figure 37).

2001:

5C Teleki, 5BB Kober and Ramsey all had a significantly higher percent nitrogen in the juice (0.068, 0.068 and 0.71% respectively) compared to all other rootstocks (Figure 37). Fercal was significantly lower in juice nitrogen compared to 5C Teleki, 5BB Kober and Ramsey(0.058%), but still significantly higher than all the remaining rootstocks, 116-60 Lider, 1103 Paulsen and 101-14, which had nitrogen contents of 0.044, 0.048 and 0.047% respectively (Figure 37).

2002:

Ramsey had a significantly higher percent nitrogen in the juice (0.072%) compared to all other rootstocks (Figure 37). 1103 Paulsen had a significantly lower percent nitrogen content in the juice (0.043%) compared to all other rootstocks except for 5BB Kober and Fercal (0.044 and 0.048%, Figure 37).

3 Year Summary:

Ramsey/Teleki > 101-14/1103 Paulsen/116-60 Lider/5BB Kober/Fercal

(l) Total Phenolics (au/g)

2000:

116-60 Lider and 5BB Kober were significantly lower in phenolic content (0.58 and 0.57au/g respectively) in comparison to Ramsey. 101-14, 1103 Paulsen and 5C Teleki did not differ significantly from any of the rootstocks (Figure 38).

2001:

5BB Kober had a significantly higher phenolic content in the berries (0.71 au/g) compared to all other rootstocks, except for 1103 Paulsen, 116-60 Lider and 5C Teleki, which had contents of 0.67, 0.63 and 0.64 au/g respectively (Figure 38). 101-14, Ramsey and Fercal had the lowest phenolic contents with 0.56, 0.58 and 0.53 au/g respectively (Figure 38).

2002:
5C Teleki had a significantly lower concentration of total phenolics (0.74au/g) compared to 1103 Paulsen, 5BB Kober and Ramsey (0.86, 0.87 and 0.86au/g respectively, Figure 38). 101-14, 116-60 Lider and Fercal were not significantly different from any of the other rootstocks being evaluated (Figure 38).

3 Year Summary:
1103 Paulsen/5BB Kober/Ramsey > 101-14/116-60 Lider/5C Teleki/Fercal

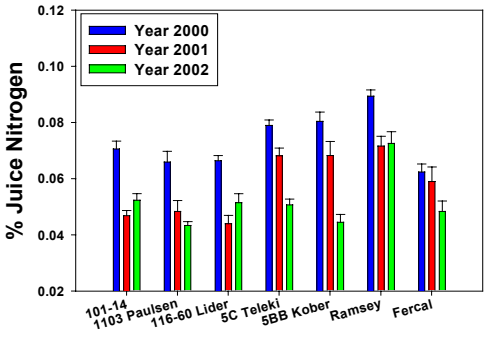


Figure 37.

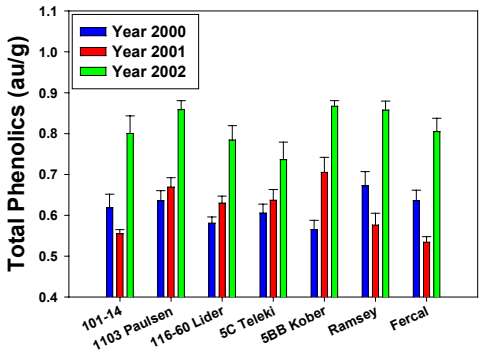


Figure 38.

4.6.3 Cabernet Sauvignon

(a) Yield (kg/vine)

2000:

1103 Paulsen, 140 Ruggeri and Ramsey had a significantly higher average yield per vine (27.6, 29.5 and 25.2kg/vine respectively) compared to 101-14, 5BB Kober and Fercal, which had yields per vine of 17.6, 14.3 and 17.1kg/vine respectively (Figure 39). The average yield per vine of 5C Teleki did not differ significantly to any of the other rootstocks (Figure 39).

2001:

101-14, 1103 Paulsen, Ramsey and Fercal had a significantly higher average yield per vine (8.96, 10.86, 10.12 and 10.08kg/vine respectively) than 5C Teleki and 5BB Kober which had average yields of 5.40 and 6.54kg/vine respectively (Figure 39). 140 Ruggeri (7.52 kg/vine) did have a significantly higher yield than 5C Teleki, but did not differ from any other rootstock in the trial (Figure 39).

2002:

140 Ruggeri, 5C Teleki and 5 BB Kober had a significantly lower yield (11.18, 9.40 and 9.57 kg/vine respectively) than all other rootstocks (Figure 39).

3 Year Summary:

1103 Paulsen/Ramsey> 140 Ruggeri/Fercal > 5C Teleki/101-14 > 5BB Kober

(b) Bunch number per vine

2000:

5BB Kober and Fercal had a significantly lower average bunch number per vine (181 and 227 bunches/vine respectively) compared to 101-14, 1103 Paulsen, 140 Ruggeri and Ramsey, which had 310, 294, 319 and 287 bunches per vine respectively (Figure 40). There were no significant differences in bunch number per vine for 5C Teleki (Figure 40).

2001:

1103 Paulsen and Fercal had a significantly higher average bunch number per vine (251.2 and 251.6 bunches/vine respectively) compared to 5BB Kober, which had 160.9 bunches per vine (Figure 40). There were no significant differences in bunch number per vine for 101-14, 140 Ruggeri, 5C Teleki and Ramsey to any other rootstock tested in the trial (Figure 40).

2002:

1103 Paulsen and Fercal had a significantly higher number of bunches per vine (311.8 and 307.6 respectively) than 140 Ruggeri, 5C Teleki and 5BB Kober (230.2, 229.3 and 213.1 respectively, Figure 40). Both 101-14 and Ramsey did not differ significantly from any of the rootstocks being evaluated (Figure 40).

3 Year Summary:

1103 Paulsen > 101-14/Ramsey/Fercal > 140 Ruggeri/5C Teleki > 5BB Kober

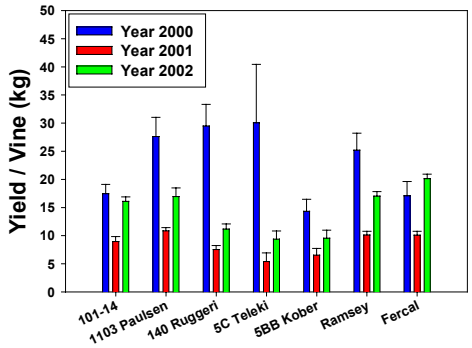


Figure 39.

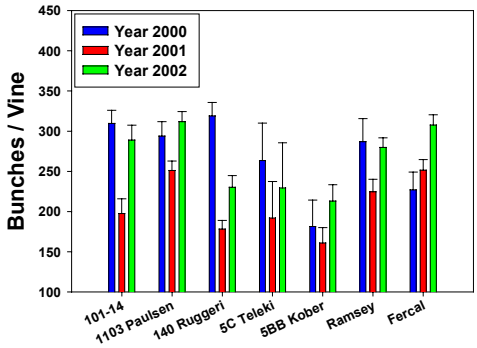


Figure 40.

(c) Average bunch weight (g)

2000:

101-14 had a significantly lower average bunch weight (55.6 g/bunch) compared to all other rootstocks (Figure 41).

2001:

There was no significant differences in the average bunch weight of all rootstocks grafted to Cabernet Sauvignon (Figure 41).

2002:

Both Ramsey and Fercal had significantly higher average bunch weights (60.9 and 65.4g respectively) compared to 140 Ruggeri (48.6g), 5C Teleki (41.0g) and 5BB Kober (44.9g, Figure 41). Both 101-14 and 1103 Paulsen were not significantly different to any of the rootstocks being evaluated (Figure 41).

3 Year Summary:

Ramsey/1103 Paulsen > 140 Ruggeri/5C Teleki/5BB Kober/Fercal > 101-14

(d) Average berry weight (g)

2000:

1103 Paulsen had a significantly lower average berry weight (0.64 g/berry) compared to 5BB Kober and Ramsey, which had average berry weights of 0.71 and 0.75 g/berry respectively (Figure 42). 101-14, 140 Ruggeri, 5C Teleki and Fercal did not differ significantly from any of the other rootstocks (Figure 42).

2001:

140 Ruggeri had a significantly lower average berry weight (0.64 g/berry) compared to Fercal, which had average berry weights of 0.78 g/berry (Figure 42). 101-14, 1103 Paulsen, 5C Teleki, 5BB Kober and Ramsey did not differ significantly from any other rootstocks (Figure 42).

2002:

Ramsey and Fercal had significantly larger berries (0.76 and 0.79g respectively) compared to 1103 Paulsen (0.64g), 140 Ruggeri (0.57g), 5C Teleki (0.62g) and 5BB Kober (0.61g, Figure 42). 101-4 had significantly larger berries (0.71g) than only 140 Ruggeri (0.57g, Figure 42).

3 Year Summary:

Fercal/Ramsey/101-14/5C Teleki > 1103 Paulsen/140 Ruggeri/5BB Kober

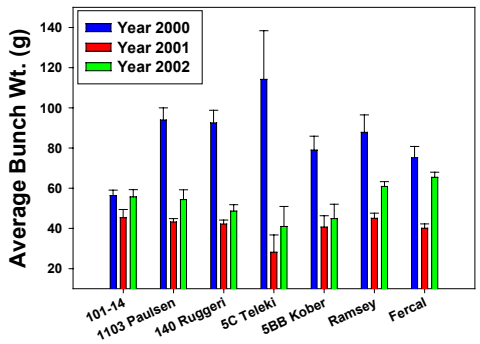


Figure 41.

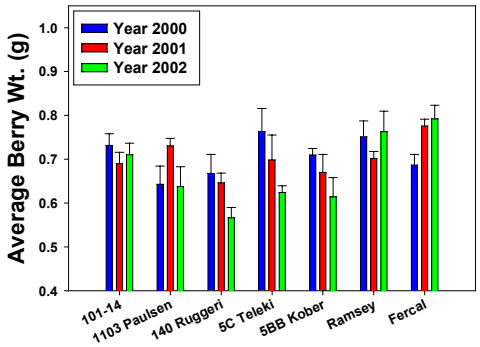


Figure 42.

(e) ^{o}Brix/^{o}Baume

The aim was to harvest all Cabernet Sauvignon rootstocks at 13.5 Baume (24.3°Brix). However, significant differences in maturity were observed.

2000:

101-14 and 1103 Paulsen did have a significantly lower Baume/$^{\circ}$Brix (12.6 and 12.5 Baume respectively) compared to 140 Ruggeri, Ramsey and Fercal, which had Baumes of 13.2, 13.3 and 13.2 respectively (Figure 43). 5C Teleki and 5BB Kober did not differ significantly in maturity compared to any of the rootstocks (Figure 43). 101-14 was harvested on the 14/3/00, almost 2 weeks earlier than any of the other rootstocks, which were all harvested on the 25/3/00 (Figure 43).

2001:

There were no significant differences in the maturity of these rootstocks (Figure 43). The rootstocks were all harvested within a day of each other with 101-14, 5C Teleki, 5BB Kober and Fercal all being harvested on the 5/3/01 (Figure 43). 1103 Paulsen, 140 Ruggeri and Ramsey were harvested on the 6/3/00 (Figure 43).

2002:
There were no significant differences in the maturity of these rootstocks (Figure 43).
3 Year Summary:
101-14 > 1103Paulsen/140 Ruggeri/5C Teleki/5BB Kober/Ramsey/Fercal

(f) pH
2000:
101-14 and 5BB Kober had a significantly lower average juice pH (3.76 and 3.77 respectively) compared to 1103 Paulsen and 140 Ruggeri, which both had a pH of 3.89 (Figure 44). 5C Teleki, Ramsey and Fercal had a juice pH, which did not differ significantly from any of the other rootstocks (Figure 44).
2001:
101-14, 140 Ruggeri and Ramsey had a significantly higher average juice pH (4.03, 3.99 and 3.97 respectively) compared to 5C Teleki, which had a pH of 3.79 (Figure 44). 1103 Paulsen, 5BB Kober and Fercal had a juice pH of 3.92, 3.94 and 3.87 respectively and did not differ significantly from any of the other rootstocks (Figure 44).
2002:
101-14 had a significantly higher average juice pH (3.88) compared to both 5BB Kober (3.76) and Fercal (3.69, Figure 44). Fercal had a significantly lower average juice pH compared to 1103 Paulsen, 140 Ruggeri, 5C Teleki and Ramsey (3.79, 3.85, 3.78 and 3.80 respectively, Figure 44).
3 Year Summary:
101-14/1103 Paulsen/140 Ruggeri/Ramsey > 5C Teleki/5BB Kober/Fercal

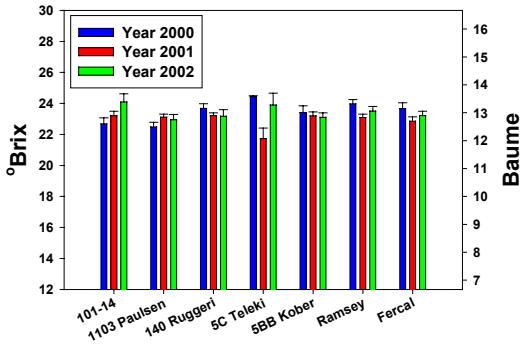


Figure 43.

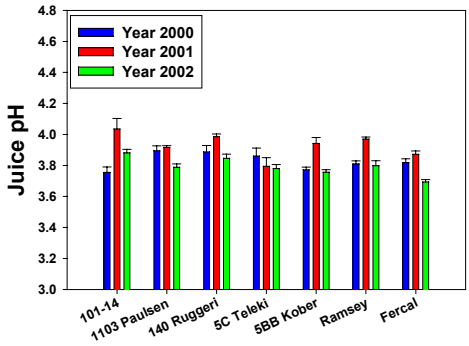


Figure 44.

(g) Titratable Acidity (g/L)
2000:
101-14 had a significantly lower titratable acidity (3.77 g/L) compared to all other rootstocks (Figure 45). Ramsey did have a significantly higher titratable acidity (5.34 g/L) compared to all other rootstocks (Figure 45). 1103 Paulsen, 140 Ruggeri, 5C Teleki, 5BB Kober and Fercal were all in the middle of the range with titratable acidities of 4.75, 4.73, 5.02, 4.56 and 4.72g/L respectively (Figure 45).
2001:
There were no significant differences in the titratable acidity of any of the rootstocks (Figure 45).
2002:
Fercal had a significantly higher average titratable acidity (4.34g/L) compared to 101-14, 1103 Paulsen, 140 Ruggeri, 5C Teleki and 5BB Kober (3.73, 3.98, 3.73, 3.86 and 3.94g/L respectively, Figure 45). Ramsey (4.07g/L) did not differ significantly from any of the other rootstocks (Figure 45).
3 Year Summary:
Ramsey/Fercal > 1103 Paulsen/5C Teleki > 140 Ruggeri/5BB Kober > 101-14

(h) Juice potassium (mM)
2000:
101-14 had a significantly lower concentration of potassium in the juice (35.9mM) compared to all other rootstocks (Figure 46). This was approximately half the concentration observed in all other rootstocks (Figure 46).

2001:
There were no significant differences in the concentration of potassium in the juice from any of the rootstocks tested in the trial during the 2000/01 season (Figure 46).
2002:
There were no significant differences in the concentration of potassium in the juice from any of the rootstocks tested in the trial during the 20001/02 season (Figure 46).
3 Year Summary:
Ramsey/Fercal/1103 Paulsen/5C Teleki/140 Ruggeri/5BB Kober > 101-14

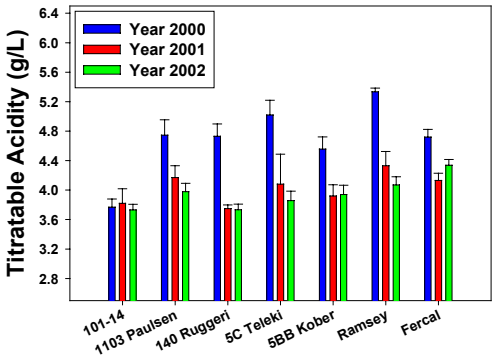


Figure 45.

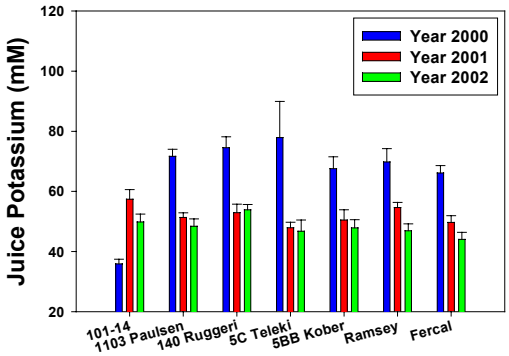


Figure 46.

(i) Juice Sodium (mM)
2000:
There was no significant difference in the average concentration of sodium, in the juice, across all the different rootstocks (Figure 47).
2001:
101-14 had a significantly higher concentration of sodium in the juice (1.3mM) when compared to Fercal which had a concentration of 1.02mM (Figure 44). There was no significant differences in the remaining rootstocks (Figure 47).
2002:
There was no significant difference in the average concentration of sodium, in the juice, across all the different rootstocks (Figure 47).
3 Year Summary:
1103 Paulsen/5C Teleki > 101-14/140 Ruggeri/5BB Kober/Ramsey/Fercal

(j) Juice Chloride (mM)
2000:
101-14 had a significantly lower concentration of chloride in the juice (0.73mM) compared to all other rootstocks (Figure 48). In the remaining rootstocks, 140 Ruggeri had significantly higher concentrations of chloride in the juice (1.12mM) compared to 1103 Paulsen and Ramsey (0.93 and 0.99mM respectively, Figure 48).
2001:
Fercal had a significantly lower concentration of chloride in the juice (0.62mM) compared to 5BB Kober and Ramsey which had juice chloride concentrations of 0.84 and 0.85mM respectively (Figure 48). 101-14, 1103 Paulsen, 140 Ruggeri and 5C Teleki did not differ significantly from any of the rootstocks (Figure 48).
2002:
Fercal had a significantly lower average juice chloride concentration (0.70mM) compared to 140 Ruggeri, 5C Teleki and 5BB Kober (0.90, 0.90 and 0.92mM respectively, Figure 48). 101-14, 1103 Paulsen and Ramsey did not differ significantly from any of the rootstocks being evaluated (Figure 48).
3 Year Summary:
101-14 > 140 Ruggeri/5C Teleki/5BB Kober/Ramsey > 1103 Paulsen/Fercal

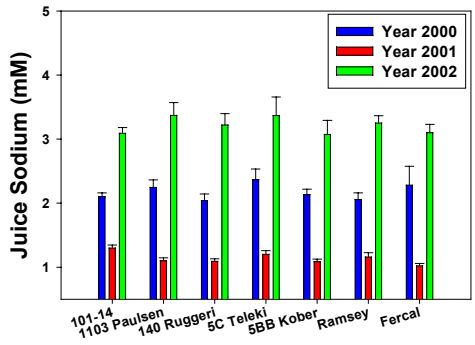


Figure 47.

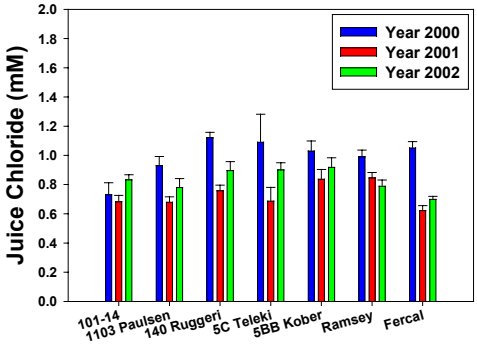


Figure 48.

(k) Juice nitrogen (% total)

2000:

101-14 and Fercal had a significantly lower percent of nitrogen in the juice (0.088 and 0.098% respectively) compared to 1103 Paulsen which had a juice nitrogen of 0.132% (Figure 49). The remaining rootstocks (140 Ruggeri, 5C Teleki, 5BB Kober and Ramsey) did not differ significantly to any of the other rootstocks (Figure 49).

2001:

140 Ruggeri, 5BB Kober and Fercal had a significantly lower percent of nitrogen in the juice (0.053, 0.052 and 0.050% respectively) compared to 5C Teleki which had a juice nitrogen of 0.075% (Figure 49). The remaining rootstocks (101-14, 1103 Paulsen and Ramsey) did not differ significantly to any of the other rootstocks (Figure 49).

2002:

There was no significant difference in the average percentage of nitrogen in the juice across all the different rootstocks (Figure 49).

3 Year Summary:

No real consistent differences were observed.

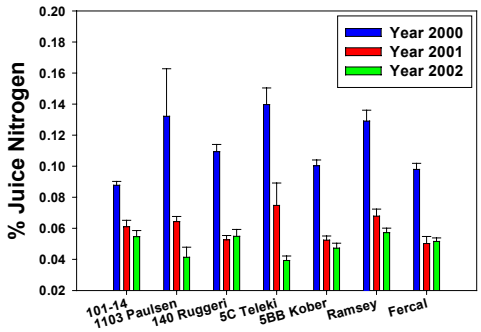


Figure 49.

(l) Colour (mg anthocyanin/g)

2000:

101-14 had significantly lower concentration of anthocyanin in the fruit (1.09 mg/g) compared to all other rootstocks, except 1103 Paulsen and 5BB Kober which had concentrations of 1.12 and 1.21mg/g respectively (Figure 50). 140 Ruggeri, 5C Teleki and Fercal had significantly higher anthocyanin levels (1.29, 1.39 and 1.27mg/g respectively) in comparison to all other rootstocks except for 5BB Kober and Ramsey (both had 1.22mg/g, Figure 50).

2001:

There were no significant differences in the concentration of anthocyanin in the fruit any of the rootstocks (Figure 50).

2002:

5C Teleki and 5BB Kober had significantly higher anthocyanin contents in the fruit (1.35 and 1.24mg/g respectively) compared to 101-14, 1103 Paulsen, 140 Ruggeri, Ramsey and Fercal (0.93, 0.93, 1.03, 0.96 and

0.74mg/g respectively, Figure 50). Fercal was also significantly lower (0.74mg/g) compared to 140 Ruggeri (1.03mg/g, Figure 50).

3 Year Summary:

5C Teleki > 140 Ruggeri/5BB Kober > 101-14/1103 Paulsen/Ramsey/Fercal

(m) Total phenolics (au/g)

2000:

101-14 had a significantly lower concentration of phenolics in the fruit (0.99au) compared to all other rootstocks, which had phenolic contents ranging between 1.36 and 1.47au (Figure 51).

2001:

101-14 had a significantly lower concentration of phenolics in the fruit (1.17 au/g) compared to 140 Ruggeri and Fercal, which had phenolic contents of 1.42 and 1.43 au/g respectively (Figure 51). The remaining rootstocks (1103 Paulsen, 5C Teleki, 5BB Kober and Ramsey) did not differ significantly from any other rootstock (Figure 51).

2002:

5C Teleki had significantly higher levels of phenolics (1.43au/g) compared to all other rootstocks (Figure 51). 101-14, 140 Ruggeri and 5BB Kober had significantly higher (1.22, 1.22 and 1.21au/g respectively) levels of phenolics compared to Fercal (0.97au/g).

3 Year Summary:

5C Teleki/140 Ruggeri > 5BB Kober/1103 Paulsen/Ramsey/Fercal > 101-14

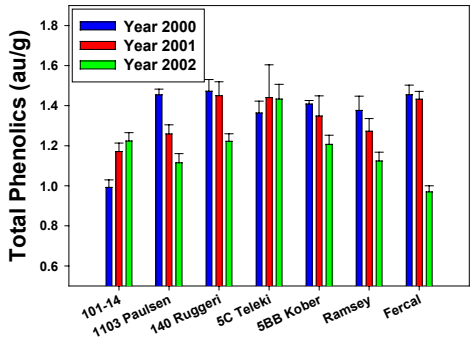


Figure 50.

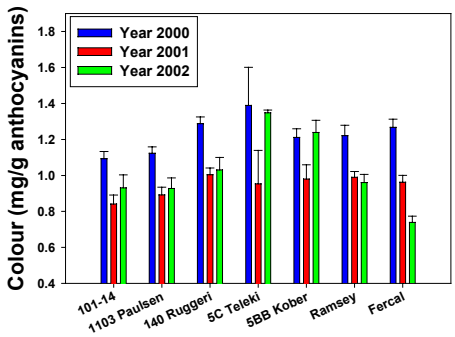


Figure 51.

5.0 Outcomes and Conclusion

In 2000, the early ripening characteristics of the 101-14 rootstock in all varieties examined was very interesting, especially in the Shiraz trial, where a 6 week difference in ripening dates was observed. The 101-14 also tended to have a large number of small bunches; this was more pronounced in the Chardonnay and Cabernet Sauvignon rootstock trials. The earlier ripening characteristics of 101-14 resulted in lower juice pH and higher titratable acidity, except in Cabernet Sauvignon. However, because of the atypical weather conditions experienced it is difficult to draw any firm conclusions. Analysis of the 1999-2000 weather data revealed that above average rainfalls occurred in both November and February. Weather conditions during the 2000-2001 season were hotter and drier than the district average. The 2001/2002 season experienced dry months between November and January. However, on the whole it was also cooler than the district average.

1999/2000 Season Summary:

The best performers in the 1999/2000 season grafted to Shiraz were:
- **101-14** – early ripening, medium yield, low berry weights, low sodium and low chloride, medium potassium, low pH, high TA, mid-range levels of nitrogen, anthocyanins and phenolics.
- **Ramsey** – late ripening, high yield, high bunch weight and high bunch number, low berry weight, high nitrogen, high potassium, high sodium, medium chloride, high nitrogen, high pH, low TA, but mid-range levels of phenolics and anthocyanins.

The best performers in the 1999/2000 season grafted to Chardonnay were:
- **101-14** – early ripening, medium yield, high bunch numbers, low bunch weight, medium berry weight, medium levels of pH and TA, low potassium and low chloride, mid-range levels of phenolics.
- **5C Teleki** – early ripening, high yield, high bunch number, medium bunch weight, medium berry weight, medium pH, high TA, medium potassium, medium nitrogen, medium chloride, low sodium and mid-range levels of phenolics.
- **Fercal** – medium ripening, medium yield, medium bunch number, medium bunch weight, medium berry weight, low pH, high TA, low potassium, medium chloride and sodium, high levels of phenolics.

The best performers in the 1999/2000 season grafted to Cabernet Sauvignon were:
- **140 Ruggeri** – medium ripening, high yield and bunch number, medium bunch and berry weight, high pH, medium TA, high potassium and chloride, medium nitrogen and sodium, high phenolics and anthocyanins.
- **101-14** – early ripening, low yield, high bunch numbers, low bunch weights, medium berry weight, low pH and TA, low potassium, nitrogen and chloride, medium sodium, low phenolics and anthocyanins.
- **5C Teleki** – medium ripening, medium yield, bunch number and weight, medium berry weight, medium pH and TA, high potassium, medium nitrogen, chloride and sodium, high phenolics and anthocyanins.

2000/2001 Season Summary:

The best performers in the 2000/2001 season grafted to Shiraz were:
- **101-14 -** early ripening, small berries, low pH, mid-range TA, good colour and phenolics
- **1103 Paulsen -** good yield, small berries, mid-range colour and phenolics

The best performers in the 2000/2001 season grafted to Chardonnay were:
- **101-14 -** early ripening, mid-sized berries, low pH, high TA, lower phenolics
- **116-60 Lider -** early ripening, high yield, mid-sized berries, low pH, high TA, lower phenolics

The best performers in the 2000/2001 season grafted to Cabernet Sauvignon were:
- **140 Ruggeri -** mid-range yield, low pH, medium TA, high colour and phenolics
- **1103 Paulsen -** high yield, medium TA, good colour and phenolics
- **Fercal -** high yield, low pH, high TA, good colour and phenolics

2001/2002 Season Summary:

The best performers in the 2001/2002 season grafted to Shiraz were:
- **101-14 -** early ripening, mid-range yield, small berries, low pH, mid-range TA, high colour and phenolics
- **1103 Paulsen –** early ripening, mid-range yield, small berries, mid-range colour and phenolics

The best performers in the 2001/2002 season grafted to Chardonnay were:
- **101-14 -** early ripening, good yield, mid-sized berries, low pH, high TA, lower phenolics
- **116-60 -** early ripening, high yield, mid-sized berries, low pH, high TA, lower phenolics
- **1103 Paulsen** - high yield, mid-sized berries, low pH, high TA, lower phenolics

The best performers in the 2001/2002 season grafted to Cabernet Sauvignon were:
- **101-14 -** mid-range yield, smaller berries, low pH, high TA, high colour and phenolics
- **5C Teleki –** mid-range yield, smaller berries, high colour and phenolics
- **1103-Paulsen –** mid-range yield, smaller berries, high TA, mid-range colour and phenolics

Summary of performance over 3 years:

The best performers grafted to Shiraz (1999-2002) were:
- **101-14 -** early ripening, mid-range yield, small berries, low pH, mid-range TA, high colour and phenolics
- **1103 Paulsen –** earlier ripening, mid-range yield, small berries, mid-range colour and phenolics

The best performers grafted to Chardonnay (1999-2002) were:
- **101-14 -** early ripening, good yield, mid-sized berries, low pH, high TA, lower phenolics
- **116-60 -** earlier ripening, high yield, mid-sized berries, low pH, high TA, lower phenolics
- **1103 Paulsen** - high yield, mid-sized berries, low pH, high TA, lower phenolics

The best performers grafted to Cabernet Sauvignon (1999-2002) were:
- **5C Teleki –** mid-range yield, smaller berries, high colour and phenolics
- **140 Ruggeri -** mid-range yield, low pH, medium TA, high colour and phenolics
- **101-14 –** earlier ripening, mid-range yield, smaller berries, low pH, high TA, high colour and phenolics

6.0 Budget Reconciliation

Budget Item	Funding from MVWIDC	Funding from GWRDC	Actual Expenditure
DNRE Salaries	18,143		18,500
Casual Harvest Labour		8,000	8,150
NRE sample analysis	1,572	2,000	3,660
NRE computer charge	1,000		1,200
NRE telephone charges	500		450
NRE travel costs	3,200		3,200
CSIRO lab charge		1,000	1,000
CSIRO winemaking charge		4,000	4,000
TOTALS	**24,415**	**15,000**	**40,160**
Total Project Funding	**39,415**	**Remitted to GWRDC**	**0**

7.0 Acknowledgments

We would like to sincerely thank the MVWIDC, VMVWGGC and GWRDC for the funding to do this project. We would also like to thank Barry Avery and Dennis Mills for their helpful assistance over the harvest period. We would also like to thank Yasmin Chalmers, Graeme Fletcher and Glenda Kelly for their technical assistance over the past year. Finally we would like to thank John Hiskins and Nolene Treloar (AVS Pty. Ltd.) for organising the legal documentation for the project.

8.0 References

Coombe, B.G. (1995). Adoption of a system of identifying grapevine growth stages. *Australian Journal of Grape and Wine Research* Vol **1** (2), pp 104-110.

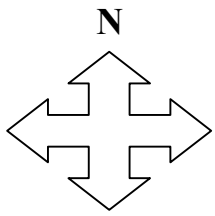
Coombe B.G and Dry P.R (1988) *Viticulture Volume 1. Resources*. Winetitles: Adelaide.

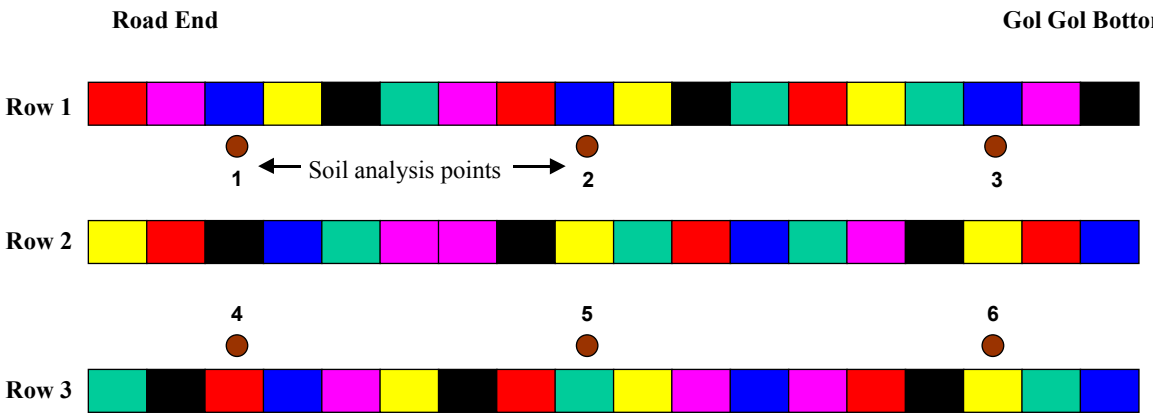
Iland, P., Ewart, A., Sitters, J., Markides., A. and Bruer, N. (2000). *Techniques for chemical analysis and quality monitoring during winemaking.* Patrick Iland Wine Promotions, South Australia.

McCarthy, M.G. (2000). Developmental variation in sensitivity of *Vitis vinifera* L. cv. Shiraz berries to soil water deficit. *Australian Journal of Grape and Wine Research* Vol **6**(2), pp 136-140.

Pearson, R.C. and Goheen, A.C. (1988) *Compendium of Grape Diseases*. APS Press: USA.

Appendix 1 – Shiraz Trial Design: Dennis Mills





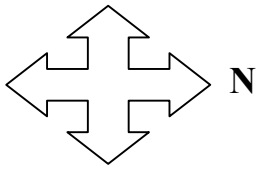
Key

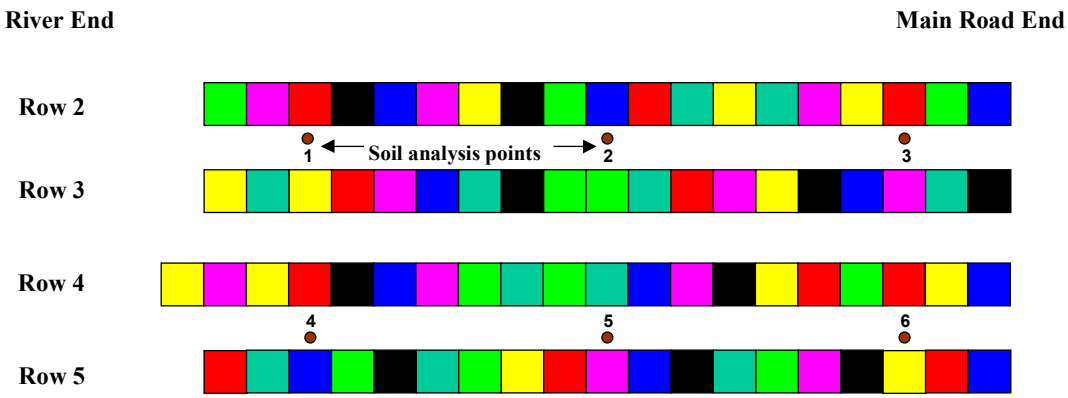
- 101-14 (9 reps)
- Ramsey (9 reps)
- 1103 Paulsen (9 reps)
- 5C Teleki (9 reps)
- 5BB Kober (9 reps)
- 116-60 (9 reps)

Guard Vines

	Road End	Gol Gol Bottom End
Row 1	2 Fercal vines	4 140 Ruggeri vines
Row 2	2 Fercal vines	4 1103 Paulsen vines
Row 3	2 140 Ruggeri vines	4 1103 Paulsen vines

Appendix 2 – Chardonnay Trial Design: Barry Avery





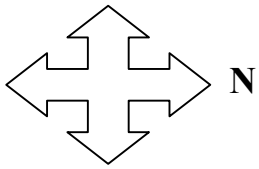
Key

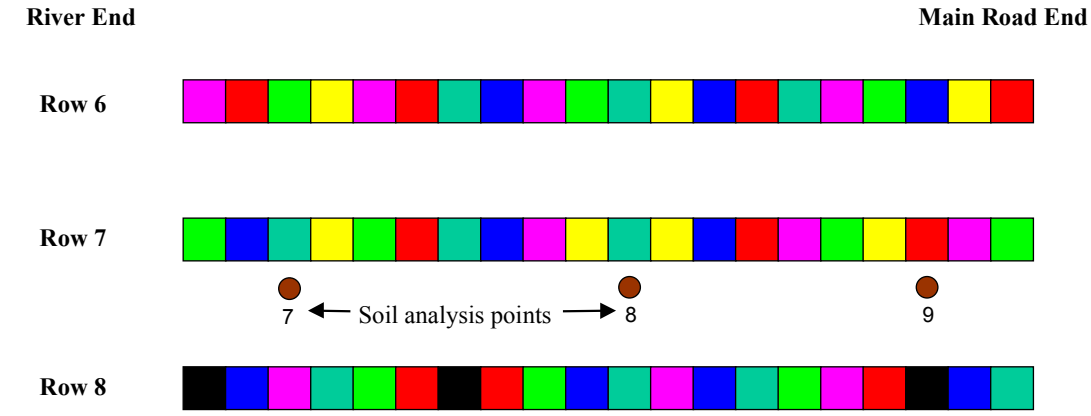
- 101-14 (11 reps)
- Ramsey (11 reps)
- 1103 Paulsen (11 reps)
- 5C Teleki (10 reps)
- 5BB Kober (12 reps)
- Fercal (11 reps)
- 116-60 (11 reps)

Guard Vines

	River End	Main Road End
Row 2	3 140 Ruggeri vines	2 140 Ruggeri vines
Row 3	4 140 Ruggeri vines	2 1103 Paulsen vines
Row 4	2 1103 Paulsen vines	2 1103 Paulsen vines
Row 5	3 1103 Paulsen vines	5 Ramsey vines

Appendix 3 – Cabernet Sauvignon Trial Design: Barry Avery





Key

- 101-14 (10 reps)
- Ramsey (10 reps)
- 1103 Paulsen (10 reps)
- 5C Teleki (3 reps)
- 5BB Kober (7 reps)
- Fercal (10 reps)
- 140 Ruggeri (10 reps)

Guard Vines

	River End	Main Road End
Row 6	3 1103 Paulsen vines	2 1103 Paulsen vines
Row 7	4 1103 Paulsen vines	2 1103 Paulsen vines
Row 8	7 1103 Paulsen vines	2 1103 Paulsen vines

Appendix 4 – Rootstock Characteristics

Rootstock	Species Origin	Scion Vigour	Vegetative Cycle	Nematode Resistance			Phylloxera Resistance	Lime Tolerance	Acid Tolerance	Salinity	Comments
				Rootknot	DaggerRoot	Lesion					
Ramsey	V.champini	high	v. long	high	low	high	high	moderate	moderate	good	Well suited to coarse-textured soils of low fertility. Susceptible to Zn deficiency. Muscat Gordo Blanco and Barlinka are incompatible with this stock. Hot to warm areas, sandy soils.
101-14	V. riparia V. rupestris	low to moderate	short	moderate	moderate	moderate	high	moderate	poor	good	Shallow root system and require deep moist soils. Hot to warm areas, range of soils.
1103 Paulsen	V.berlandieri V. rupestris	moderate	long	moderate to high	moderate	-	high	Moderate	good	good	Imparts drought tolerance to scions. Moderately tolerant of salt. Warm to cool areas, range of soils.
5C Teleki	V.berlandieri V. riparia	moderate	medium	moderate	moderate	-	v. high	moderate	poor	poor	Cool region rootstock. Warm to cool areas, range of soils.
5BB Kober	V.berlandieri V. riparia	low to moderate	medium	moderate	moderate	-	v. high	moderate	poor	poor	Best suited to moist, compact soils. Warm to cool areas, range of soils.
Fercal *	V.berlandieri x berlandieri - colombard No. 1 x 333 EM	moderate	-	Susceptible	-	-	-	high	-	-	-
140 Ruggeri	V.berlandieri V. rupestris	high	v. long	moderate	low	-	high	high	good	good	Imparts considerable drought tolerance to scions. Hot to warm areas, range of soils.
116-60 Lider *	V. canicans 1613C	-	-	-	-	-	-	-	-	-	-

* Because these varieties are relatively new to Australia, little is known about their characteristics.

References:

(G. Fletcher pers. com., 2000)
Coombe B.G and Dry P.R (1988) Viticulture. Volume 1. Resources. Winetitles: Adelaide

Table 1

Shiraz Rootstock Data for Summarised for 1999/00, 2000/01 and 2001/02 Seasons

Note - statistical significance (p<0.05) indicated by different letters. 'ns' = not significant. Only comparable within each individual year

Year	Rootstock	Yield/ Vine (kg)	Bunches/ vine	Average Bunch Wt. (g)	Average Berry Wt. (g)	Harvest °Brix	Juice pH	Titratable Acidity (g/L)	K (mM)	Na (mM)	Cl (mM)	N %	Colour (mg/g)	Total Phenolics (au/g)
2000	**101-14**	8.93 ab	127.1 ns	69.15 ns	1.02 a	26.08 a	3.67 ab	5.31 a	63.04 ns	2.51 a	1.72 ab	0.060 a	1.24 a	1.17 a
	1103 Paulsen	12.24 ac	154.0 ns	79.87 a	0.92 a	23.35 b	3.57 ab	5.16 a	56.83 a	2.43 a	1.57 ab	0.050 a	1.02 b	0.97 b
	116-60	13.11 ac	160.9 a	82.72 a	0.97 a	24.86 ns	3.82 bc	4.18 b	64.16 ns	4.04 bc	2.87 c	0.069 b	0.88 b	0.92 b
	5C Teleki	6.80 b	132.1 ns	47.26 b	0.99 a	24.45 ns	3.73 bc	4.38 b	61.34 ns	3.40 ab	2.38 cb	0.072 b	1.20 a	1.30 a
	5BB Kober	6.33 b	112.4 b	53.29 b	0.72 b	25.53 a	3.79 bc	4.49 b	56.06 a	2.53 a	2.11 b	0.076 bc	1.54 c	1.51 c
	Ramsey	14.43 c	165.7 a	87.03 a	0.97 a	25.04 ns	3.94 c	4.27 b	70.36 b	4.61 c	2.04 b	0.090 c	1.10 a	1.21 a
2001	**101-14**	12.08 ac	185.0 ns	65.30 a	1.26 ns	24.17 a	4.10 a	3.53 a	57.56 a	1.48 a	1.06 a	0.058 ab	0.94 a	1.02 a
	1103 Paulsen	15.73 ab	195.5 ns	80.44 ab	1.20 ns	22.74 b	4.51 b	3.05 b	53.74 ns	1.24 a	0.84 a	0.059 bc	0.70 b	0.84 bc
	116-60	18.10 b	213.6 ns	84.74 b	1.32 ns	22.32 b	4.10 a	3.93 c	52.23 ns	1.94 b	1.35 b	0.061 bc	0.75 b	0.85 bc
	5C Teleki	10.42 ac	148.5 ns	70.15 a	1.22 ns	22.00 b	4.56 b	2.98 b	46.78 b	1.39 a	0.89 a	0.058 ab	0.86 ns	0.94 ab
	5BB Kober	11.79 ac	156.6 ns	75.29 ab	1.18 ns	22.78 b	3.91 c	3.71 ac	43.06 b	1.01 a	0.86 a	0.049 a	1.07 a	1.01 ab
	Ramsey	19.38 b	199.4 ns	97.19 c	1.27 ns	23.14 c	4.98 d	3.08 b	51.59 ns	2.18 b	1.15 ns	0.067 c	0.66 b	0.74 c
2002	**101-14**	13.42 a	232.4 a	57.75 a	0.76 a	23.46 a	3.63 a	3.38 ns	34.33 a	4.53 ns	1.06 a	0.031 a	1.38 a	1.45 a
	1103 Paulsen	13.88 a	176.2 b	78.80 a	0.88 ab	23.63 a	3.86 b	3.41 ns	55.98 bc	5.81 ns	1.35 a	0.056 b	1.18 ab	1.27 ab
	116-60	21.30 b	184.0 b	115.76 b	1.05 b	21.38 b	3.83 b	3.53 ns	54.14 bc	4.97 ns	2.31 b	0.047 c	0.95 bc	1.17 bc
	5C Teleki	11.45 a	165.2 b	69.35 a	0.83 ac	24.06 a	3.76 b	3.47 ns	47.55 c	4.51 ns	2.04 b	0.044 c	1.39 a	1.32 ab
	5BB Kober	12.24 a	193.1 ns	63.40 a	0.87 ab	23.99 a	3.67 a	3.93 ns	48.24 c	4.06 ns	1.05 a	0.046 c	1.30 a	1.29 ab
	Ramsey	23.56 b	223.0 a	105.65 b	0.97 bc	20.69 b	3.83 b	3.62 ns	57.39 b	5.36 ns	1.31 a	0.053 b	0.74 c	1.03 c
3 Year Av.	**101-14**	11.48	181.50	64.06	1.01	24.57	3.80	4.07	51.64	2.84	1.28	0.05	1.19	1.21
	1103 Paulsen	13.95	175.23	79.70	1.00	23.24	3.98	3.87	55.51	3.16	1.25	0.05	0.96	1.03
	116-60	17.50	186.16	94.40	1.11	22.85	3.92	3.88	56.84	3.65	2.18	0.06	0.86	0.98
	5C Teleki	9.56	148.57	62.25	1.01	23.50	4.02	3.61	51.89	3.10	1.77	0.06	1.15	1.18
	5BB Kober	10.12	154.01	63.99	0.92	24.10	3.79	4.04	49.12	2.53	1.34	0.06	1.30	1.27
	Ramsey	19.12	196.02	96.62	1.07	22.96	4.25	3.66	59.78	4.05	1.50	0.07	0.83	0.99

Table 2

Chardonnay Rootstock Data for Summarised for 1999/00, 2000/01 and 2001/02 Seasons

Note - statistical significance (p<0.05) indicated by different letters. 'ns' = not significant. Only comparable within each individual year

Year	Rootstock	Yield/ Vine (kg)	Bunches/ vine	Average Bunch Wt. (g)	Average Berry Wt. (g)	Harvest °Brix	Juice pH	Titratable Acidity (g/L)	K (mM)	Na (mM)	Cl (mM)	N %	Total Phenolics (au/g)
2000	**101-14**	16.49 ns	202.3 a	81.53 a	0.95 ns	23.60 a	3.60 ab	5.31 a	52.84 a	1.44 a	0.72 a	0.071 a	0.62 ns
	1103 Paulsen	15.65 a	156.3 b	100.17 b	0.98 ns	22.84 ns	3.57 ab	5.22 a	55.89 ns	1.25 b	0.62 b	0.066 ad	0.64 ns
	116-60	18.11 ns	174.0 ns	104.08 b	0.99 ns	22.71 b	3.60 ab	5.23 a	56.60 b	1.41 a	0.94 c	0.066 ad	0.58 ab
	5C Teleki	19.38 b	192.9 ns	100.47 b	0.99 ns	22.86 ns	3.58 ab	5.54 b	53.33 ns	1.26 b	0.66 ab	0.079 b	0.61 ns
	5BB Kober	17.38 ns	156.8 b	110.84 b	0.93 ns	22.64 b	3.61 b	4.95 c	54.95 ns	1.34 a	0.66 ab	0.080 b	0.57 ab
	Ramsey	18.60 b	181.8 ns	102.30 b	0.96 ns	22.55 b	3.59 ab	5.28 a	53.83 ns	1.49 a	0.70 ab	0.089 c	0.67 c
	Fercal	17.52 ns	171.0 ns	102.45 b	0.98 ns	22.30 b	3.50 c	5.48 b	52.43 a	1.39 ns	0.70 ab	0.062 d	0.64 bc
2001	**101-14**	14.91 ns	290.5 a	51.31 a	0.80 a	21.14 ns	3.83 a	4.56 a	54.85 a	0.95 ab	0.40 a	0.047 a	0.56 a
	1103 Paulsen	13.24 ns	233.6 ns	56.65 a	0.69 b	21.85 ns	3.98 b	3.73 b	57.57 a	0.87 ac	0.88 b	0.048 a	0.67 bc
	116-60	15.75 ns	294.0 a	53.56 a	0.82 a	21.26 ns	3.97 b	3.97 c	55.85 a	1.18 b	0.65 c	0.044 a	0.63 bc
	5C Teleki	12.38 ns	242.4 ns	51.07 a	0.74 c	21.55 ns	4.28 c	3.29 de	68.00 b	0.98 ab	1.01 b	0.068 c	0.64 bc
	5BB Kober	14.48 ns	263.2 a	55.03 a	0.73 c	21.18 ns	4.22 c	3.12 d	57.00 a	0.73 c	0.93 b	0.068 c	0.71 c
	Ramsey	14.07 ns	256.2 a	54.93 a	0.77 ac	21.36 ns	4.04 d	3.71 b	58.08 a	0.98 ab	0.77 bc	0.071 c	0.58 ab
	Fercal	11.91 ns	178.4 b	66.77 b	0.81 a	21.71 ns	4.23 c	3.41 e	63.30 b	0.79 ac	0.89 b	0.059 b	0.53 a
2002	**101-14**	15.73 ns	231.8 ns	67.84 a	0.86 ab	22.96 ns	3.61 ns	4.47 ab	49.46 a	2.74 a	0.52 ab	0.052 a	0.80 ns
	1103 Paulsen	15.24 ns	222.5 ns	68.46 ab	0.83 ab	22.26 ns	3.56 a	4.44 ab	42.75 b	2.65 a	0.50 ab	0.043 b	0.86 a
	116-60	14.15 ns	202.9 ns	69.71 ab	0.91 b	22.53 ns	3.62 ns	4.65 a	48.44 a	3.79 b	0.84 c	0.051 a	0.78 ns
	5C Teleki	12.72 ns	185.2 ns	68.68 ab	0.81 a	22.25 ns	3.59 ab	4.39 ab	46.98 ac	3.58 b	0.60 ab	0.050 a	0.74 b
	5BB Kober	11.95 ns	175.2 ns	68.22 ab	0.93 bc	22.03 ns	3.65 bc	3.82 c	44.22 bc	2.68 a	0.45 ad	0.044 ab	0.87 a
	Ramsey	14.95 ns	193.6 ns	77.18 bc	0.97 c	23.06 ns	3.69 c	3.99 bc	47.35 ac	3.36 b	0.56 b	0.072 c	0.86 a
	Fercal	16.20 ns	200.2 ns	80.93 c	0.99 c	22.28 ns	3.60 ab	4.18 b	45.76 ns	2.61 a	0.41 d	0.048 ab	0.81 ns

3 Year Av.	**101-14**	15.71	241.55	66.90	0.87	22.57	3.68	4.78	52.38	1.71	0.55	0.06	0.66
	1103 Paulsen	14.71	204.16	75.10	0.83	22.32	3.70	4.47	52.07	1.59	0.67	0.05	0.72
	116-60	16.00	223.64	75.78	0.91	22.17	3.73	4.62	53.63	2.13	0.81	0.05	0.66
	5C Teleki	14.83	206.83	73.41	0.85	22.22	3.81	4.41	56.10	1.94	0.76	0.07	0.66
	5BB Kober	14.61	198.38	78.03	0.86	21.95	3.83	3.96	52.06	1.58	0.68	0.06	0.71
	Ramsey	15.87	210.54	78.14	0.90	22.33	3.77	4.33	53.09	1.95	0.68	0.08	0.70
	Fercal	15.21	183.18	83.38	0.93	22.10	3.78	4.36	53.83	1.60	0.67	0.06	0.66

Table 3

Cabernet Sauvignon Rootstock Data for Summarised for 1999/00, 2000/01 and 2001/02 Seasons

Note - statistical significance (p<0.05) indicated by different letters. 'ns' = not significant. Only comparable within each individual year

Year	Rootstock	Yield/ vine (kg)	Bunches/ vine	Average Bunch Wt. (g)	Average Berry Wt. (g)	Harvest °Brix	Juice pH	Titratable Acidity (g/L)	K (mM)	Na (mM)	Cl (mM)	N %	Colour (mg/g)	Total Phenolics (au/g)
2000	**101-14**	17.45 a	309.7 a	55.58 a	0.73 ns	22.68 a	3.76 a	3.77 a	35.93 a	2.10 ns	0.73 a	0.088 a	1.09 a	0.99 a
	1103 Paulsen	27.61 b	294.0 a	93.00 b	0.64 a	22.49 a	3.89 b	4.75 b	71.66 b	2.24 ns	0.93 b	0.132 b	1.12 ab	1.45 b
	140 Ruggeri	29.49 b	319.0 a	91.90 b	0.67 ns	23.68 b	3.89 b	4.73 b	74.55 b	2.04 ns	1.12 c	0.109 ns	1.29 c	1.47 b
	5C Teleki	30.05 ns	263.3 ns	108.09 b	0.76 ns	24.43 ns	3.86 ns	5.02 b	77.93 b	2.37 ns	1.09 bc	0.140 ns	1.39 c	1.36 b
	5BB Kober	14.33 a	181.4 b	82.68 b	0.71 b	23.41 ns	3.77 a	4.56 b	67.57 b	2.13 ns	1.03 bc	0.100 ns	1.21 ns	1.41 b
	Ramsey	25.21 b	287.0 a	86.87 b	0.75 b	23.97 b	3.81 ns	5.34 c	69.79 b	2.06 ns	0.99 b	0.129 ns	1.22 bc	1.38 b
	Fercal	17.08 a	227.0 b	74.40 b	0.69 ns	23.67 b	3.82 ns	4.72 b	66.15 b	2.28 ns	1.05 bc	0.098 a	1.27 c	1.46 b
2001	**101-14**	8.96 a	197.6 ns	45.34 ns	0.69 ns	23.21 ns	4.03 a	3.82 ns	57.43 ns	1.30 a	0.68 ns	0.061 ns	0.84 ns	1.17 a
	1103 Paulsen	10.86 a	251.2 a	43.23 ns	0.73 ns	23.11 ns	3.92 ns	4.17 ns	51.34 ns	1.10 ns	0.68 ns	0.064 ns	0.89 ns	1.26 ns
	140 Ruggeri	7.52 ab	178.2 ns	42.20 ns	0.65 a	23.22 ns	3.99 a	3.75 ns	52.92 ns	1.09 ns	0.76 ns	0.053 a	1.00 ns	1.45 b
	5C Teleki	5.40 c	192.0 ns	28.13 ns	0.70 ns	21.73 ns	3.79 b	4.08 ns	47.97 ns	1.20 ns	0.69 ns	0.075 b	0.95 ns	1.44 ns
	5BB Kober	6.54 bc	160.9 b	40.67 ns	0.67 ns	23.20 ns	3.94 ns	3.92 ns	50.49 ns	1.09 ns	0.84 a	0.052 a	0.98 ns	1.35 ns
	Ramsey	10.12 a	224.6 ns	45.06 ns	0.70 ns	23.09 ns	3.97 a	4.33 ns	54.65 ns	1.16 ns	0.85 a	0.068 ns	0.99 ns	1.27 ns
	Fercal	10.08 a	251.6 a	40.06 ns	0.78 b	22.86 ns	3.87 ns	4.13 ns	49.69 ns	1.02 b	0.62 b	0.050 a	0.96 ns	1.43 b
2002	**101-14**	16.10 a	289.0 ns	55.71 ns	0.71 ac	24.10 ns	3.88 a	3.73 a	49.87 ns	3.09 ns	0.83 ns	0.055 ns	0.93 ac	1.22 a
	1103 Paulsen	16.94 a	311.8 a	54.33 ns	0.64 ab	22.95 ns	3.79 ab	3.98 a	48.44 ns	3.37 ns	0.78 ns	0.041 ns	0.93 ac	1.12 ac
	140 Ruggeri	11.18 b	230.2 b	48.57 a	0.57 b	23.18 ns	3.85 ab	3.73 a	53.90 ns	3.22 ns	0.90 a	0.055 ns	1.03 a	1.22 a
	5C Teleki	9.40 b	229.3 b	40.99 a	0.62 ab	23.90 ns	3.78 ab	3.86 a	46.77 ns	3.37 ns	0.90 a	0.039 ns	1.35 b	1.43 b
	5BB Kober	9.57 b	213.1 b	44.91 a	0.61 ab	23.10 ns	3.76 bc	3.94 a	47.87 ns	3.07 ns	0.92 a	0.047 ns	1.24 b	1.21 a
	Ramsey	17.04 a	279.8 ns	60.90 b	0.76 c	23.50 ns	3.80 ab	4.07 ns	46.90 ns	3.25 ns	0.79 ns	0.057 ns	0.96 ac	1.12 ac
	Fercal	20.12 a	307.6 a	65.41 b	0.79 c	23.22 ns	3.69 c	4.34 b	44.07 ns	3.10 ns	0.70 b	0.052 ns	0.74 c	0.97 c
3 Year Av.	**101-14**	14.17	265.43	52.21	0.71	23.33	3.89	3.77	47.74	2.16	0.75	0.07	0.95	1.13
	1103 Paulsen	18.47	285.67	63.52	0.67	22.85	3.87	4.30	57.15	2.24	0.80	0.08	0.98	1.28
	140 Ruggeri	16.06	242.47	60.89	0.63	23.36	3.91	4.07	60.46	2.12	0.92	0.07	1.11	1.38
	5C Teleki	14.95	228.22	59.07	0.70	23.36	3.81	4.32	57.56	2.31	0.89	0.08	1.23	1.41
	5BB Kober	10.15	185.14	56.09	0.66	23.24	3.82	4.14	55.31	2.10	0.93	0.07	1.14	1.32
	Ramsey	17.46	263.80	64.28	0.74	23.52	3.86	4.58	57.11	2.16	0.88	0.08	1.06	1.26
	Fercal	15.76	262.07	59.96	0.75	23.25	3.79	4.40	53.30	2.13	0.79	0.07	0.99	1.29