Coonawarra Rootstock Trial

Looking back and looking forward

Report initially prepared by Nick Dry (Foundation Viticulture) in June 2020 and
added to by Suzanne McLoughlin (Vinehealth Australia) in October 2020

Acknowledgements

The project team gratefully acknowledge:

- The $30,000 funding by Wine Australia through the Limestone Coast Grape and Wine Council for the small lot winemaking and Pivot tasting.
- The continued funding of this trial by Coonawarra Vignerons and South Australian vineyard owners through Vinehealth Australia.
- Treasury Wine Estates for their in-kind contribution of operational management of the trial site and allowing the project team and local grapegrowers and winemakers access to the site.
- The in-kind contributions of many personnel who have played a part in the trial to date.

Contents

Acknowledgements **2**

Abstract **4**

Executive Summary **5**

Background **7**

Aim **9**

Methodology **10**

Site description 10

Trial design 11

Trial management 12

Data collection 12

Climate Observations 14

Field walks 15

Results **16**

Viticulture data collection- V15, V16 and V19 16

Viticulture data collection V19 19

Observations from the V19 field walk 21

Wine Measurements V19 23

Potassium 24

Pivot tasting 24

Summary of rootstock performance based principal biplot analysis 24

Discussion **27**

Rootstock influence on vine vigour and associated canopy measurements 27

Rootstock influence on yield and wine quality 28

Summary of Discussion 29

Addendum **32**

Regaining vine balance 32

Virus testing 32

Rootstock root structure and volume 32

Trial future 32

References **33**

Appendix 1 – AWRI Small Scale Red Fruit Winemaking Protocol **34**

Appendix 2 – AWRI Pivot tasting report **35**

Abstract

The key objective of the project was to compare the performance of 8 rootstocks (1103 Paulsen, 140 Ruggeri, 110 Richter, Ramsey, Börner , Merbein 5489, Merbein 6262, Merbein 5512) and an own rooted control using Cabernet Sauvignon as the scion variety. The trial was set-up using a replicated, randomised design and viticulture data collection occurred over three seasons 2014/2015, 2015/2016 and 2018/2019 with small-lot wines produced in 2019. The trial showed that rootstock has a significant effect on yield, vine vigour and wine style. It also highlighted the potential of new rootstocks Merbein 5489, Merbein 5512 and Börner for the Limestone Coast region.

Executive Summary

The Coonawarra Rootstock Trial established in 2009, is a long-term partnership between Coonawarra Vignerons, Treasury Wine Estates and Vinehealth Australia and is the only formally-managed rootstock trial of this type in South Australia.

The aim of this trial is to increase the level of knowledge on rootstock performance in the Limestone Coast by comparing 8 rootstocks (Merbein 5489, Merbein 5512, Merbein 6262, 140 Ruggeri, 1103 Paulsen, Ramsey, Börner, 110 Richter) and an own rooted control on the principle soil type of the Coonawarra. The trial was setup to facilitate scientific analysis, with both a randomised, replicated section of seven rows from which three years of viticultural measures have been recorded, as well as 27 commercially managed rows. Viticultural data collection was undertaken in the 2014/2015 (V15), 2015/2016 (V16) and 2018/2019 (V19) growing seasons. Winemaking was completed in the V19 season.

It is recognised that increased knowledge of rootstock performance in the region will help growers in the Limestone Coast be more confident in making a rootstock selection that is appropriate for their site. This will in turn increase rootstock use in the Limestone Coast and ultimately provide greater biosecurity preparedness from the threat of phylloxera.

The trial results suggest that new rootstock’s Merbein 5489, Merbein 5512 and Börner have good potential in the region and this should provide impetus for commercial plantings of these rootstocks. It must be stated however that the Merbein rootstocks have been hard to access by industry because the establishment of mothervines and subsequent distribution has been limited to two nurseries only. The current model for the supply of these CSIRO developed rootstocks needs to be reviewed to allow for wider access by industry to ensure that there is broader uptake on the significant industry investment into the development of these rootstocks.

Overall the trial results showed that the influence of rootstock on vine vigour was a key factor in explaining vine performance related to yield, wine quality and style and has highlighted the challenges of managing a replicated trial with rootstocks which inherently impart different levels of vigour to the scion. If one were to take a narrow view of the trial results, then it would be possible to quickly dismiss some of the rootstocks in this trial as not suitable to the climatic conditions in the Coonawarra. However, it was the homogenous management regime, coupled with the climatic conditions that led to the relatively poor performance of the higher vigour rootstocks. Further trial

work needs to be undertaken to understand how the high vigour/drought tolerant rootstocks can be consistently managed for quality outcomes under the conditions of the region.

Background

Australia has some of the oldest grapevines in the world. This important resource has remained due to the absence of many of the damaging pests and disease impacting vineyards overseas. One of these pests is grape phylloxera, a small insect pest that damages vines by feeding on their roots. Vine death can result after approximately five years. There is no chemical or biological control for phylloxera and the only mechanism grape growers can employ to combat phylloxera is to plant vines grafted to American rootstocks. Grafted vine material however comes at a cost of at least 2.5 times that of own rooted material - $4,000 per hectare for own roots compared with grafted vines $10,000.

With the acknowledgement of a rise in phylloxera detections in Australia over the last 10 years, particularly associated with the outbreak in the Yarra Valley in Victoria, grape growers are starting to look at planting or replanting a proportion of their vines to grafted vines as an insurance policy. This activity is occurring in conjunction with heightened awareness and adherence to best practice farmgate hygiene practices to prevent phylloxera and other pests and diseases from entering at the property level.

Rootstock use in the grape and wine industries is not just to combat pests such as phylloxera or nematodes. Rootstocks can also be used as viticultural tools to help improve drought tolerance, manipulate vine vigour, provide tolerance to saline, calcareous or acidic soils and reduce potassium uptake (Dry, 2007). With high awareness by viticultural industries of the effects of climate change on grape production, growers are placing more value on drought tolerance and water use efficiency in situations where water for agricultural use is becoming less available.

Coonawarra, like other regions in South Australia, has had a low level of vines planted to rootstock. Currently the region has 13.1% area under vine planted to rootstocks (source: Vinehealth Australia). Rootstock use is not dissimilar across the rest of the Limestone Coast.

The Coonawarra Rootstock Trial established in 2009, is a long-term partnership between Coonawarra Vignerons, Treasury Wine Estates and Vinehealth Australia and is the only formally-managed rootstock trial of this type in South Australia.

The trial was setup to facilitate scientific analysis, with both a randomised, replicated section of seven rows from which three years of viticultural measures have been recorded, as well as 27 commercially managed rows. The trial includes eight rootstocks and an own rooted control. The rootstocks are: Merbein 5489 (M5489), Merbein 5512 (M5512), Merbein 6262 (M6262), 140 Ruggeri, 1103 Paulsen, Ramsey, Börner, 110 Richter and own roots.

Viticultural data collection was undertaken in the 2014/2015 (V15), 2015/2016 (V16) and 2018/2019 (V19) growing seasons. Winemaking was completed in the V19 season using grapes from the randomised section only.

Aim

The aim of this trial is to increase the level of knowledge on rootstock performance in the Limestone Coast by comparing the 8 rootstocks and own rooted control on the principle soil type of the Coonawarra across the randomised rows. This will be achieved with:

(a) Scientific assessment through viticultural data collection and winemaking (in V19).

(b) Field walks that allow growers and winemakers the opportunity to visually compare, contrast and assess performance between rootstocks and own roots in a commercial setting.

Increased knowledge of rootstock performance in their region will help growers in the Limestone Coast be more confident in making a rootstock selection that is appropriate for their site. This will in turn increase rootstock use in the Limestone Coast and ultimately provide greater biosecurity preparedness from the threat of phylloxera.

Data collection across the three seasons has also provided the opportunity to evaluate performance of rootstocks under different seasonal conditions. This will help develop knowledge on which rootstocks may be better suited for tackling issues related to climate change including reduced access to water, increased temperature across the growing season and increased frost and heat-wave events.

There are still perceptions within some parts of the wine industry that grafted vines cannot produce the wine quality reflective of the character of the region and so an additional aim of this trial is to enhance the awareness of the ability of grafted vines to reflect the desired quality and style of the region.

The trial has also provided the opportunity to evaluate the performance of some rootstocks that have yet to be widely planted in commercial vineyards including Börner, M6262, M5512 and M5489.

The final aim of this trial is to raise the profile of the Limestone Coast as a centre of excellence for grapevine rootstock knowledge.

Methodology

Site description

Location and planting details

The trial is located on Treasury Wine Estates 'Alexander Vineyard' in Coonawarra, South Australia and vines were planted across two seasons. In November 2009, the treatments 110 Richter, Ramsey, 1103 Paulsen, Börner, 140 Ruggeri and own roots were established using dormant rootlings and in November 2010, M6262, M5489, M5512 were established with green potted vines. The delay in planting the Merbein stocks until 2009 was due to the unavailability of planting material.

Block details

- North-south orientation
- Vine spacing = 2m
- Row Spacing = 3.35m
- Density = 1500 vines/Ha
- Typical 'terra-rossa' soil of the region i.e. clay-loam over limestone

Clone selection

Cabernet Sauvignon clone CW44 was selected as the scion for the trial. CW44 is a clone selected from the Richardson's block in Coonawarra. It is widely planted across the region and familiar to both growers and winemakers and therefore at the time of planting, was deemed an appropriate choice for the trial.

Rootstock selection

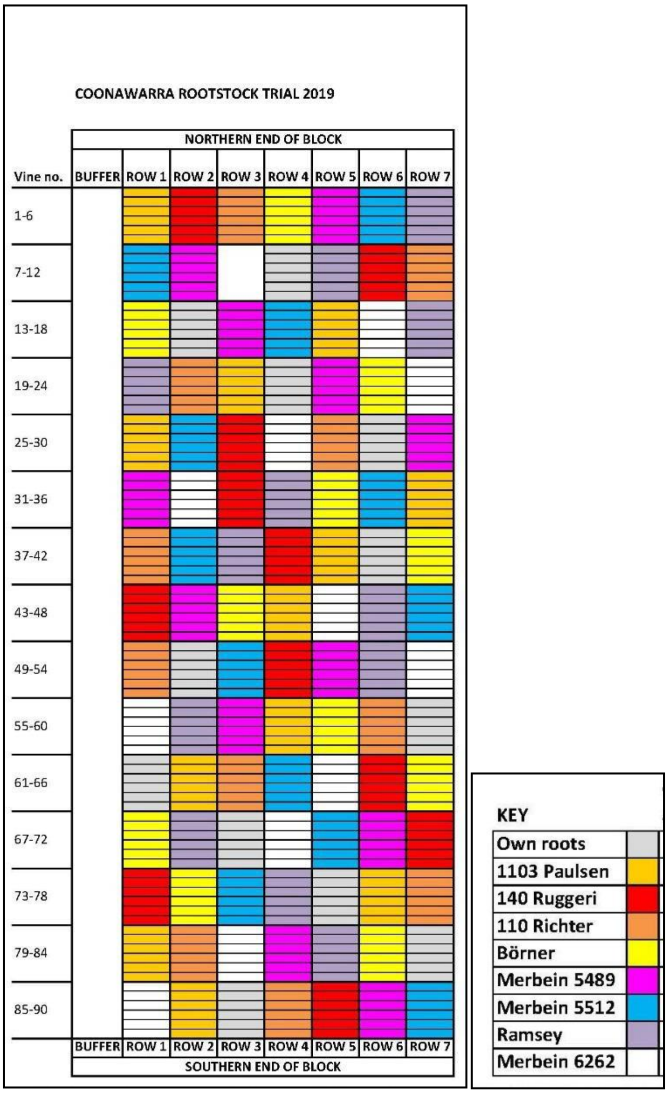
The rootstock selection process deliberately avoided rootstocks that were considered to have poor drought tolerance/water-use efficiency. The exception to this was Börner which was included because it has been reported that in some circumstances this rootstock has immunity to phylloxera (Becker, 1988). The justification for including these rootstocks was based on the desire to evaluate rootstocks that would help mitigate the impacts of climate change particularly lower water availability and heat-waves. The Merbein rootstocks; M5489, M5512 and M6262 are relatively new rootstocks developed by the CSIRO and were included because of their reported ability to increase water-use efficiency and reduce potassium uptake (Clingeleffer, 2011).

Trial design

An EM 38 survey was used to identify soil differences across the site. In Coonawarra, EM38 readings generally determine depth to limestone or the relative soil moisture holding capacity (Loder, unpublished). Three areas of differing soil depth were identified and categorised as low, medium and high. To ensure that soil depth did not become an additional variable, rootstocks were planted equally across the three identified areas.

The trial is set-up with 9 plots per treatment (6-vine plots) randomised across 7 rows but ensuring that each treatment was replicated 3 x in each vigour area.

Table. 1 Layout of rootstock treatments



Trial management

The vines in the trial were managed with an approach that reflected the standard practices of the region.

Pruning

All the vines in the trial were pruned with intention of having equal bud numbers per vine.

Canopy management

Vines were trained to a Vertical Shoot Positioned (VSP) canopy with shoot thinning and trimming undertaken based on the requirements for the season.

Irrigation

In season 2014/2015, 111 hours were applied across the growing season which equates to 1.03 ML/Ha applied. In season 2015/2016, 110 hours were applied across the growing season which equates to 1.02 ML/Ha applied. In season 2018/2019, zero irrigation was applied until week beginning 7th January. The block was then regularly irrigated up until week beginning 25th January. An 8-hour irrigation was then applied in the week beginning 18th March. The total for the growing season was 67 hours which equates to 0.62 ML/Ha applied.

Data collection

Table 2. Summary of data collection by season

	2018/19	2015/16	2014/15
Maturity (Be, TA, pH)			
Yield per vine, bunch number, bunch weight			
Berry number, berry weight			
Trunk circumference			
Cane weight			
Bud number post-pruning			
Canopy LAI/porosity			
Bunch stem necrosis bunches per vine			
Harvest juice cations and chloride			
Berry anthocyanins, tannin and phenolics			
Wine colour, tannin and phenolics			
Wine cations and chloride			
Winemaking			
Wine sensory analysis			

Data was not collected in 2017/2018 because yield per vine was impacted by a frost event in November 2017. Data was not collected in 2016/2017 because part of the trial was unintentionally harvested prior to data collection (Table 2).

Viticulture

Viticultural parameters were collected from each of 81 tagged sample vines (9 vines per treatment) across the replicated section.

Yield

In field measures of yield per vine and bunch number per vine were undertaken which enabled average bunch weight to be calculated.

Three random bunches per sample vine were retained and used for counting berry number and calculating berry weight using the "fast berry counting method". All 27 bunches per rootstock were weighed, then the bottom 10 berries were plucked off each bunch per rootstock and pooled. Each 270 berry weight was recorded per rootstock and then divided by 270 to calculate average berry weight. Each 27 bunch weight was then divided by the average berry weight per rootstock to determine average berry number per bunch.

Canopy LAI/porosity

Fraction photosynthetically active radiation was measured to assess canopy leaf area / leaf area index using a handheld ceptometer (Accupar LP-80 PAR/LAI ceptometer, Decagon Devices, Pullman, WA, USA). For each vine, a reading was taken above the canopy in full sunlight and below the canopy along the cordon line, for both sides of the cordon. Measurements were completed on the western side of the canopy.

Bunch stem necrosis

In v19 there was an observation of some rootstocks showing more bunch stem necrosis than others. Simple quantification of this difference was carried out at harvest by recording the number of bunches per vine showing bunch stem necrosis symptoms and then presenting the results as a percentage of the total number of bunches per vine.

Maturity sampling

- Weekly 12-bunch samples collected for each rootstock
- Analysed for total soluble solids (Baume), pH, titratable acidity

Trunk circumference

Measured at dripper height.

Winemaking

Small lot winemaking

Small lot wines (50-60kg) made in duplicate on all rootstocks except M6262 by AWRI using standard winemaking protocol (Appendix 1). Harvest decisions were aimed at harvesting all rootstocks between 13.8 – 14.3˚Be. All rootstocks were harvested on the same day and grapes were harvested only from the replicated section of the trial for winemaking.

Pivot analysis

As a means of comparing the wines made from the rootstocks, a selected group of trained regional winemakers was guided through a rapid sensory method called Pivot Profile" by the AWRI, whereby the own rooted wine was used as the pivot wine.

Statistical analyses

Each rootstock was subjected to one-way factorial with repeated measures analysis of variance (ANOVA) using XLSTAT Version 17.06 (Addinsoft SARL, Paris, France). The significance of the difference between treatment means was determined using Fischer's least significant difference (LSD) test calculated at the 5 % level. Principal component analysis (PCA) plots was performed in Microsoft Excel 2010 and XLSTAT Version 17.06 (Addinsoft SARL, Paris, France) and presented as variable plots (rootstock, attribute).

Climate Observations

Information sourced and adapted from the Coonawarra Vignerons Board Seasonal Reports.

2014/2015

The region experienced average winter rainfall. Spring conditions were not typical, being very dry and one of Coonawarra's warmest, with temperatures well above average. A warm and dry flowering period promoted a fast and even berry set. Yields overall were on the moderate side due to lower bunch numbers, and as a result little bunch thinning was required at veraison. Very dry conditions continued through December until 90 mm of rain fell in mid-January. Harvest was considered to be at the normal time ie – late March early April.

2015/2016

The region experienced a warmer October and November leading to earlier than normal flowering and good fruit-set. February and March temperatures were mild, and the cold nights and warm days delivered an extended ripening period. The growing season (Sept 2015 – March 2016) was drier than usual, delivering only half the normal rainfall. Yields were higher than previous years.

2018/2019

Coonawarra received good winter rains leading into the growing season. September -December temperatures were in line with the long-term average. Rainfall across the growing season was well below average. The region experienced above average temperatures in January however conditions moderated for the rest of the growing season. A cool and dry April was perfect for ripening, allowing full flavour development and optimal sugar levels. Yields of red wine grapes were between average to slightly below the long-term average.

Field walks

Public field walks of the randomised, replicated rows were held in 2017 and 2019. During the latter field walk, the 35 participants were provided with a trial map and observations sheet and asked to submit their observations for collation.

Results

Viticulture data collection- V15, V16 and V19

Yield and yield components

Table. 3. Average yield and yield components across the three years of data collection showing the significant impacts that rootstock had on these measurements.

Rootstock	Yield/vine (kg)	Bunches/vine	Bunch weight (g)
140 Ruggeri	10.1 a	106 abc	96.1 a
1103 Paulsen	9.8 ab	107 ab	91.0 ab
M5512	9.5 abc	116 a	86.9 bc
110 Richter	9.0 bc	111 a	82.6 cd
Ramsey	8.9 c	112 a	79.3 cd
M5489	7.9 d	106 abc	75.4 d
Börner	6.9 e	96 cd	74.8 d
M6262	6.1 ef	98 bcd	63.9 e
Own roots	5.4 f	93 d	57.7 e
Pr > F	0	0	0
Significant	Yes	Yes	Yes

All rootstocks across the three years of data collection produced significantly higher yields than the own rooted treatment with the exception of M6262 (Table 3). Based on average yield/vine across the three years of data collection the rootstocks can be separated into two groups; the higher yielding rootstocks (in descending order of yield) 140 Ruggeri, 1103 Paulsen, M5512, 110 Richter and Ramsey and the lower yielding rootstocks (in descending order of yield) M5489, Börner, M6262 and own roots. The two highest yielding rootstocks 140 Ruggeri and 1103 Paulsen produced almost double the yield of own roots across the three years of data collection.

Bunch number per vine had the most impact on yield across the three seasons. All rootstocks imparted higher bunch numbers per vine compared with own roots except M6262 and Börner. All rootstocks imparted higher bunch weights across the three years of data collection compared with own roots except M6262.

Table 4. Ranking of rootstocks by yield across the three years of data collection highlighted that rankings were not consistent over the period of data collection with Ramsey in particular dropping from 1st to 8th.

	V15		V16		V19	
Rootstock	Yield (kg/vine)	Ranking	Yield (kg/vine)	Ranking	Yield (kg/vine)	Ranking
Ramsey	9.9	1	12	4	4.8	8
140 Ruggeri	9.7	2	14.7	2	5.9	4
1103 Paulsen	8.9	3	15.2	1	5.4	5
M5512	7.9	4	11.7	5	8.8	1
Börner	7.8	5	7.6	7	5.3	6
M5489	7.3	6	10	6	6.4	2
110 Richter	7.2	7	13.6	3	6.3	3
M6262	6.5	7	6.4	9	5.3	7
Own roots	5.8	8	7.1	8	3.3	9

Own roots, M6262 were consistently the lowest yielding rootstock by ranking across the three years of data collection (Table 4). Own roots recorded the lowest average yield, bunch number and bunch weight across all treatments for the three years of the data collection (data not shown). M6262 was the only rootstock in the trial that recorded lower yield components compared with own roots during the three years of data collection (bunch number per vine, bunch weight and yield per vine in V16 but were not significantly lower).

Table 4 shows that the high yields in V16 recorded for 1103 Paulsen and 140 Ruggeri drove their higher average across the three years and in V19 these rootstocks ranked 4th and 5th respectively. Ramsey also shows an interesting downward trend in yield ranking from 1st in V15 to 8th in V19 (just above own roots). The fluctuations in yield were driven by decreasing bunch numbers. Coupling this data with data collected at pruning could indicate that these rootstocks were in a 'vigour cycle' (see discussion).

M5512 and M5489 rose in the yield rankings from 4th and 6th in V15 to 1st and 2nd in V19 and both showed generally good consistent yields across all three years of data collection.

Börner was consistently ranked low in yield- 5th, 7th and 6th across the three seasons.

110 Richter ranked 7th in V15 and 3rd in both V16 and V19.

Vine Vigour

Vigour rankings were very consistent across the three seasons of data collection and it is possible to categorise the rootstock treatments into 3 groups based on pruning weight/vine.

- High vigour: 1103 Paulsen and 140 Ruggeri
- Medium Vigour: 110 Richter, Ramsey, M5512 and M5489
- Low vigour: Own roots, M6262 and Börner

The two high vigour rootstocks 1103 Paulsen and 140 Ruggeri produced double the biomass of own roots across the three years of data collection (data not shown).

Table 5. Average pruning weight by rootstock across the three years of data collection (V15, V16 and V19) showed that there was a significant effect of rootstock on vine vigour. This effect is thought to have affected yield and quality.

Rootstock	Ave. pruning weight/vine (kg)
1103 Paulsen	2.3 a
140 Ruggeri	2.2 a
110 Richter	1.8 b
Ramsey	1.6 bc
M5512	1.6 c
M5489	1.5 c
Own roots	1.1 d
Börner	0.9 de
M6262	0.8 e
Pr > F	0
Significant	Yes

Ripening

The total soluble solids (Baume), titratable acidity (TA) and pH at the last collected date per season for V15, V16, V17 and V19 for each rootstock was averaged. Börner, Ramsey and own roots had the equal lowest baume average of 13.2, with M5489 having the highest average baume of 13.6 (data not shown). Own roots had the lowest TA average of 4.47, with M5489 and 140R having the equal highest average TA of 5.21 (data not shown). M5512 had the lowest pH average of 3.83, with 110R and 1103P having the equal highest average pH of 3.91 (data not shown).

Viticulture data collection V19

Yield

Yields were significantly lower in V19 compared with the other two years of data collection (data not shown). Own roots was the lowest yielding treatment and M5512 the highest yielding treatment in V19. Apart from own roots the relative rankings in V19 of the other rootstock treatments did not reflect the rankings in V15 and V16 (Table 4), with M5512, M5489 and 110 Richter ranking higher than 1103 Paulsen and 140 Ruggeri (Table 6).

Table 6. Yield/vine and yield ranking in V19 did not reflect the rankings in previous years of data collection. Both M5512 and M5489 out yielded all other rootstocks for the first time in three years of data collection.

Rootstock	Yield/vine (kg)	Ranking
M5512	8.8 a	1
M5489	6.4 ab	2
110 Richter	6.3 ab	3
140 Ruggeri	5.9 abc	4
1103 Paulsen	5.4 bc	5
Börner	5.3 bc	6
M6262	5.3 bc	7
Ramsey	4.8 bc	8
Own roots	3.3 c	9
Average	**5.72**	

Yield Components

Table 7. Yield components of the rootstock treatments in V19 showed that there was a significant effect of rootstock treatment on both bunch number per vine and bunch weight.

Rootstock	Bunches/vine	Bunch wt (g)	Berries/bunch	Berry wt (g)
M5512	80 a	111 a	114	0.92
110 Richter	69 abc	90 b	87	1.06
M5489	76 ab	83 bcd	93	0.94
140 Ruggeri	64 bcde	93 b	89	0.99
1103 Paulsen	61 de	90 bc	94	0.89
Börner	62 cde	85 bcd	99	0.77
M6262	70 abcd	76 cd	102	0.69
Ramsey	62 cde	76 d	82	0.9
Own	59 e	56 e	64	0.81
Average	**67**	**84**	**91**	**0.89**

The comparatively lower yields of 1103 Paulsen and 140 Ruggeri (in terms of their rankings compared with other seasons) (Table 6) was driven by having lower bunch numbers that were not significantly different to own roots (Table 7). Bunch weights for both rootstocks were above the average of 84g per bunch but were significantly lower than M5512 and 110 Richter.

Ramsey also ranked lower in yield compared with previous years of data collection (8th in V19 compared with 4th in V16 and 1st in V15). Similar to 1103 Paulsen and 140 Ruggeri, Ramsey did not have a bunch number that differed significantly from own roots but had a bunch weight that was significantly lower than 1103 Paulsen and 140 Ruggeri (and M5512, 110 Richter). This was driven by a lower than average berry number per bunch (82 berries per bunch compared with 92).

110 Richter was ranked third for yield per vine and had a higher than average berry weight (1.06g compared with the group average of 0.89g). Börner and M6262 both recorded low berry weights 0.77g and 0.69g compared with the group average of 0.89g.

Indices related to light penetration into the bunch zone

Table 8 shows that there is an effect of rootstock on vine vigour, leaf area and canopy density. Based on these data it can be suggested that in this trial rootstock treatment had an effect on the level of light penetration into the bunch zone. Rootstock treatments own roots, M6262 and Börner had higher levels of light penetration into the bunch zone. Treatments Ramsey and M5489, had more moderate levels of light penetration into the bunch zone and treatments 140 Ruggeri, 1130 Paulsen, M5512 and 110 Richter had lower levels of light penetration into the bunch zone.

Table 8. Impact of rootstock on vine vigour, canopy size and density as measured by pruning weight, leaf area index and canopy porosity was proposed to have had an effect on wine quality and style.

Rootstock	Pruning wt/vine (kg)	Canopy LAI	Canopy porosity
140 Ruggeri	2.4	2.50	0.16
1103 Paulsen	2.4	2.34	0.15
110 Richter	2	2.38	0.13
M5512	1.9	2.24	0.15
M5489	1.8	1.89	0.20
Ramsey	1.8	1.88	0.21
Börner	1.2	1.19	0.39
M6262	1	1.06	0.41
Own roots	0.8	0.91	0.46
Average	**1.7**	**1.82**	**0.25**

Bunch-Stem Necrosis

The proportion of bunches displaying bunch stem necrosis symptoms for each rootstock was significantly different and the higher vigour rootstocks of M5489, 110R and 1103P showed significantly higher bunch stem necrosis levels than the remaining rootstocks and own-rooted control (Figure 1). There was a moderately strong but non-significant correlation with pruning weight per vine (0.651) and trunk circumference (0.64), also somewhat indicative of vigour differences impacting bunch stem necrosis levels.

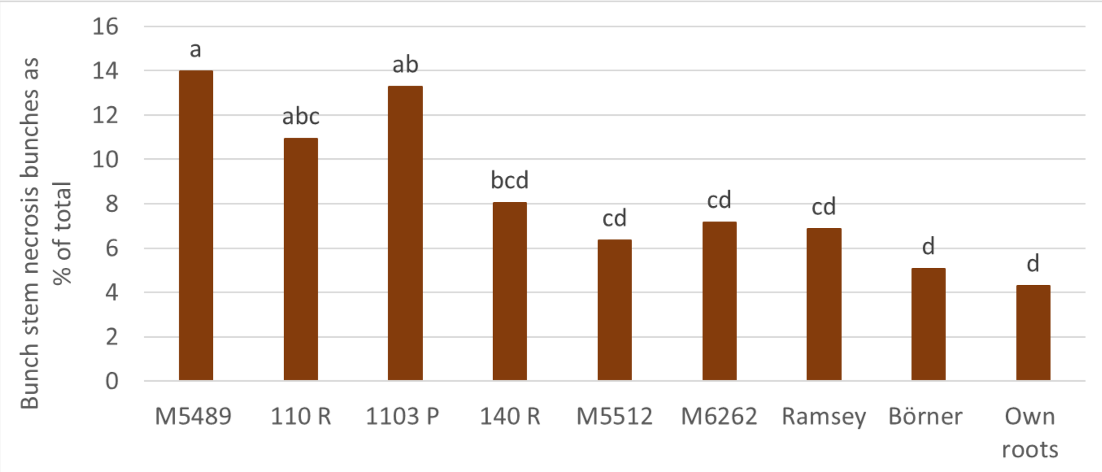


Figure 1. Impact of rootstock on % bunch-stem necrosis observed.

Observations from the V19 field walk

With the trial rows irrigated 'to the average', distinct rootstock differences were evident, especially in terms of canopy stress. The lowest vigour rootstocks of M6262 and Börner, as well as the Own Rooted control, were suffering significant water stress with yellowing canopies across all replicates. Differences in terms of bunch stem necrosis were also observed. M5489, 1103P and 110R were reported to have a significantly higher proportion of bunches with bunch stem necrosis compared to all other rootstocks except 140R. Only 11 respondents shared an actual preference for a rootstock, with M5512 receiving five votes, followed by own roots with 3 votes, followed by Ramsey and M5489 both receiving two votes, and Börner receiving one vote.

Common descriptions of the rootstocks from the observation sheets were as follows, although there was some variance in the observations, also due to the different trial rows the participants walked:

1103 Paulsen

- smaller crop load, small berries, open bunches, large canopy, good fruit set, lacking flavor, good balanced flavor, some bunch stem necrosis, moderate greens, fine tannins, crunchy skins, lots 2nd crop, noticeable lateral shoots

140 Ruggeri

- vigorous canopy, dark green foliage, good fruit set, big bunches, big berries, lovely soft tannins, tough skins, green flavours and phenolics, less 2nd crop dropped, quite acidic, very little-some bunch stem necrosis

110 Richter

- small, loose bunches with poor fruit set but variable across panels as some big and tight bunches, large berries, better fruit set and leaf colour than Ramsey, canopy comparable with 140Ruggeri but with lower yield, bitter flavours, low amount of bunch stem necrosis, vigorous and green canopy

Ramsey

- lot of second crop dropped, open and moderately vigorous canopy, longish loose bunches due to moderate fruit set, good flavour, even set, good shoot length, moderate stress with some vines showing basal leaf yellowing, comparatively light crop

Börner

- inconsistent berry size but generally small, good crop level, small canopy with lots of bunches and yellowing leaves, short shoots, canopy looks stressed and is losing leaf and now open, lower acid, slightly flat, lean flavours, some shrivel, some BSN, skinny graft union

M5489

- bunch architecture variable from open to compact, biggish berries, some BSN, tough (thick) skins and tannin, robust flavor, high yielding, big canopy, balanced, no visual stress, high acid, lot second crop dropped, moderate to large bunch size, good fruit set

M5512

- smaller berries than M5489 but bigger overall cropload, big bunches, very thick skins, lots second crop dropped, moderate vigour canopy, good flavour, even shoot development, good fruit set, some basal leaf yellowing but handles seasonal conditions well, a little shrivel, good balance

M6262

- lots of bunches, very short shoots, very stressed canopy (lot leaf yellowing, very open canopy, observations consistent across all replicates), thin trunks in comparison to other rootstocks, small canopy and especially for the cropload, lacking fruit flavours

Own roots

- small canopy, leaf yellowing indicative of drought stress, lighter cropload good for canopy size, smaller berries, more open canopy with short shoots, fewer second crop bunches dropped, poorer set – similar to Börner, looser bunches, good flavour, some bunch stem necrosis

Wine Measurements V19

Measurements associated with wine quality

Börner was the stand-out rootstock treatment in terms of wine measurements associated with wine quality. It had the highest colour density (Figure 2), the highest measurements for wine anthocyanins and phenolics (Figure 3) and the highest values of pigmented and total tannins (Figure 4). Own roots also performed well ranking highly (2nd or 3rd) in all the wine measurements. No other rootstock treatment stood out in the measurements.

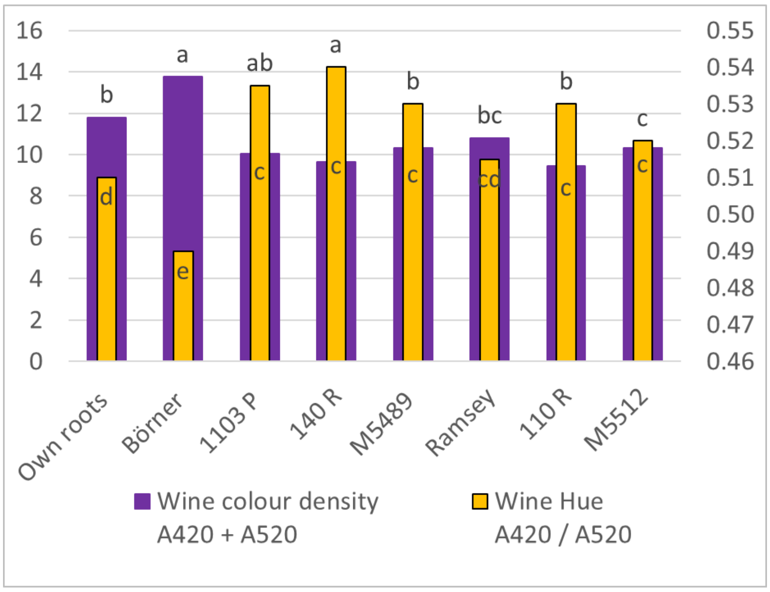


Figure 2. Influence of rootstock on wine colour and wine hue.

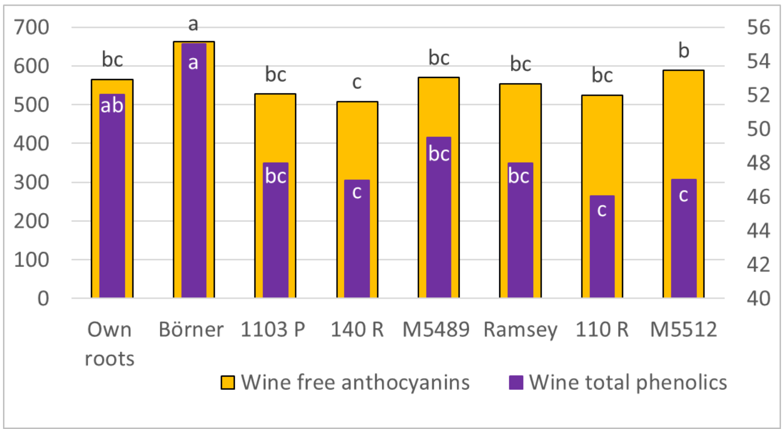


Figure 3. Influence of rootstock on wine anthocyanin and phenolic production.

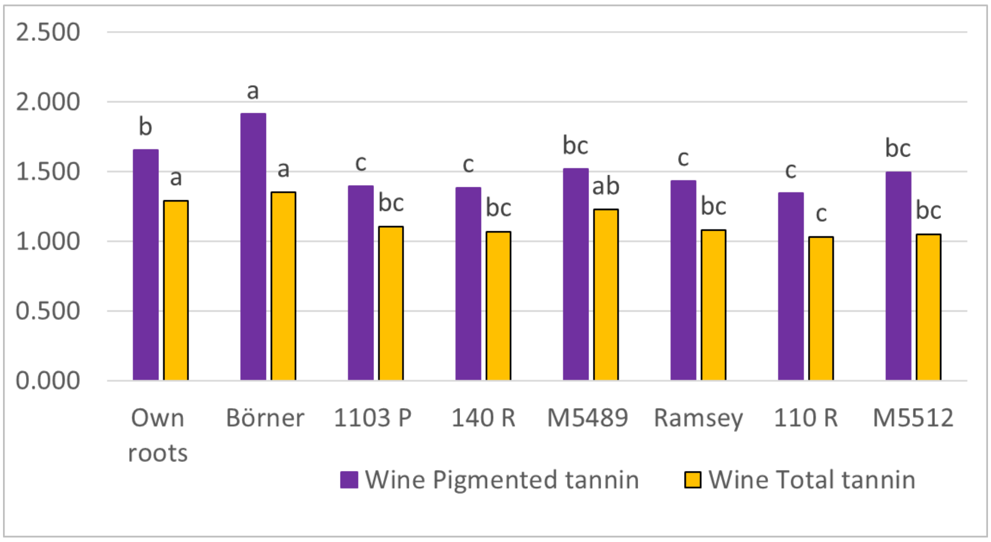


Figure 4. Influence of rootstock on wine tannin production.

Potassium

M5512 and M5489 had significantly lower juice K but this did not translate into significantly lower wine K. Higher wine K was significantly and positively correlated with vine vigour. Higher wine K was significantly and negatively correlated with wine colour density, phenolics, anthocyanin, pigmented tannin.

Pivot tasting

Wines showed varied sensory profiles, with three groups (clusters) of wines identified from the analysis. Cluster 1 consisted of the Ramsey, 110R, 140R and 1103P rootstocks and was rated high for Red colour, Red Fruit aroma and flavour, Acid, Green aroma and flavour and Herbal aroma among others. Cluster 2 contained M5512 and M5489 and the Own Roots wine, and was high in Intense and Dense appearance, Fresh, Complex and Long palate, and Earthy and Floral aroma. Cluster 3 consisted of only the Börner sample and was high in Purple colour, Dark Fruit aroma/palate, ripe aroma/palate, and Round and Dense palate. Preference scores revealed Cluster 3 to be the most liked and Cluster 1 the least liked. Refer to Appendix 2 for further information.

Summary of rootstock performance based principal biplot analysis

A principal biplot analysis was developed using the data collected in V19; included was the viticulture data, wine measurements and sensory profile and preference data (Figure 5). Based on the biplot analysis it was possible to group the rootstock treatments by similarity and describe their relative performance.

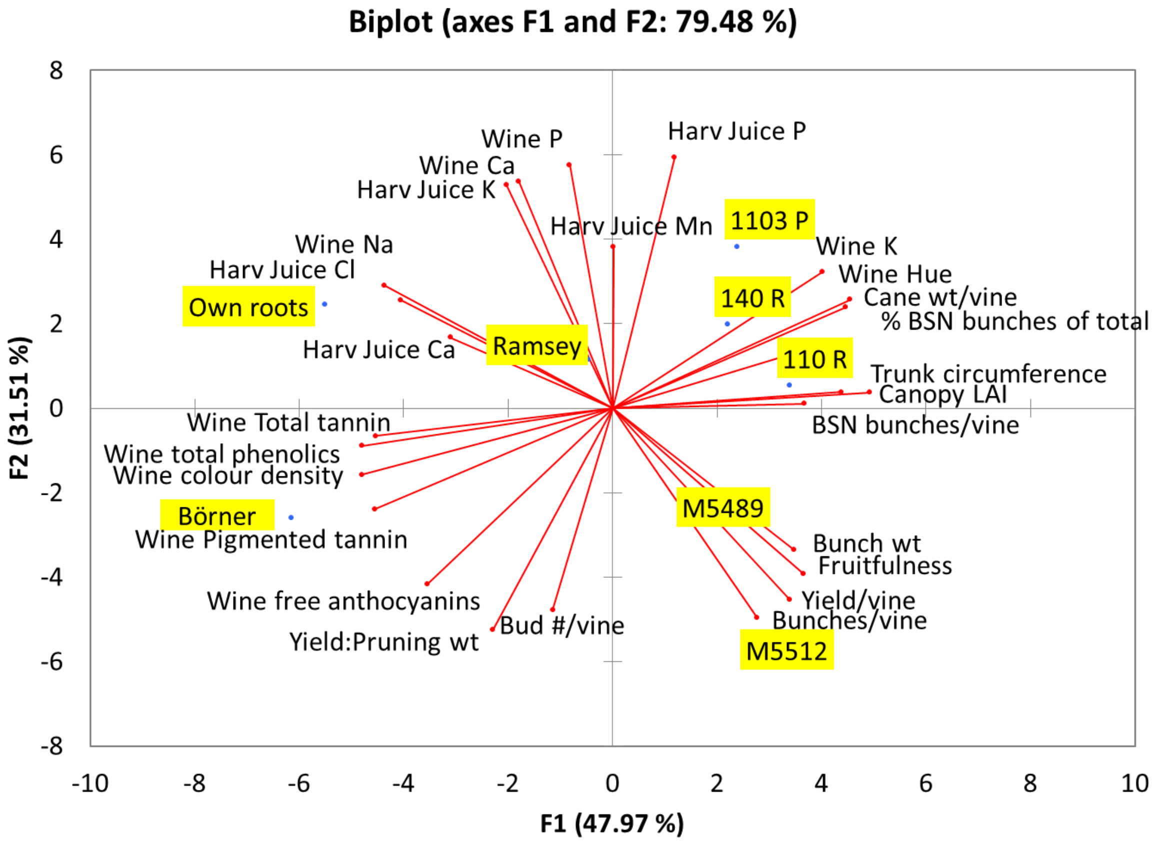


Figure 5. Principal components analysis plot for all data collected in V19 including wine sensory profile and preference from small-lot wines and the groupings of rootstocks based on these assessments.

Own Roots and Ramsey

- Lowest yield
- High ions (especially own roots)
- Lowest in crush TA and alcohol at bottling, highest in crush pH (own roots)

Wine sensory description: High in intense and dense appearance, fresh, complex and long palate, and earthy and floral aroma.

Börner

- Highest yield:pruning wt
- Slightly slower ripening
- Smallest berries
- Lowest in crush Baume
- Highest in wine colour, phenolics and tannin
- Lowest in wine hue
- Highest pivot (wine) score

Wine sensory description: High in purple colour, dark fruit aroma/ palate, ripe aroma/ palate, round and dense palate.

1103 Paulsen, 140 Ruggeri and 110 Richter

- High vigour
- Higher levels of Bunch Stem Necrosis
- Higher wine K
- Higher methoxypyrazines
- Lowest pivot (wine) score

Wine sensory description: High for red colour, red fruit aroma and flavour, acid, green aroma and flavour, herbal aroma.

M5512 and M5489

- High yielding (bunch number and weight)
- Low in ions (especially M5512)
- Lowest in harvest berry K
- Lowest YAN at crush
- Lowest crush pH
- Moderate pivot (wine) score

Wine sensory description: High in intense and dense appearance, fresh, complex and long palate, and earthy and floral aroma.

Discussion

Rootstock influence on vine vigour and associated canopy measurements

Based on the measurements associated with vine vigour (pruning weight, LAI, porosity, trunk circumference) it can be concluded that there is a strong relationship between rootstock and vine vigour and it is possible to categorise the rootstock treatments into 3 groups.

- Higher vigour: 1103 Paulsen and 140 Ruggeri
- Medium Vigour: 110 Richter, Ramsey, M5512 and M5489
- Low vigour: Own roots, M6262 and Börner

In relation to vine vigour the commercial rootstocks (1103 Paulsen, 140 Ruggeri and 110 Richter) performed as expected in that we would expect 140 Ruggeri and 1103 Paulsen to impart higher vine vigour and would expect 110 Richter to impart more medium vigour levels.

Considering that Ramsey is generally categorised as imparting higher vigour than 140 Ruggeri and 1103 Paulsen its performance is perhaps surprising, however in shallow or confined soils Ramsey is unable to employ the benefit of its tap-rooting nature and this can limit the potential to impart the 'normal' vigour levels we expect to see from Ramsey.

The data related to the lesser known rootstocks; M5512, M5489 is valuable as it provides an initial indication of their performance under these conditions and validates the other few commercial observations that have been made for these rootstocks i.e. M5489 is lower vigour compared with 140 Ruggeri and that M6262 is lower vigour compared with M5489 and M5512 (Clingeleffer, 2011).

Based on data from Germany during its early testing; Börner was categorised as high vigour but also sensitive to calcareous soils (Becker, 1988). It is likely that the categorisation of high vigour was compared with other commonly used rootstocks in Germany (5C Teleki, 5BB Kober and SO4) all of which would be considered as medium vigour rootstocks in Australia. Based on this it was not expected that Börner would produce vigour levels equal to 140 Ruggeri or 1103 Paulsen. Its performance related to vigour has likely also been impacted by its sensitivity to calcareous soils.

The influence of rootstock on vine vigour is a key factor in explaining the results related to yield, wine quality and style, as well as the homogeneity of management of the rootstocks to date.

Rootstock influence on yield and wine quality

Own roots and Börner

The rootstocks categorised as low vigour consistently produced the lowest yields across all three years of data collection and this was generally a result of lower bunch numbers per vine, lower bunch weights and based on V19 data, low berry number per bunch and berry size. This coupled with the lower vigour (more open canopies) and arguably better vine balance it is therefore not surprising that Börner and own roots performed well in the wine quality measurements. There is enough evidence from the data to suggest that Börner should be considered for further commercial evaluation.

1103 Paulsen and 140 Ruggeri

The yield rankings of the higher vigour rootstocks 1103 Paulsen, 140 Ruggeri fell significantly in V19 compared with V15 and V16. It is possible that these rootstocks are in a 'vigour cycle'. The suggestion is that the higher inherent vigour of those rootstocks coupled with a management regime that is based on the average of the rootstocks has led to the production of vines that are out of balance. By V19 this led to lower fruitfulness, lower than expected yield which in turn exacerbated vigour and led to higher levels of shading in the fruit-zone. Unsurprisingly wines made from these rootstocks had higher wine potassium and methoxypyrazines levels compared with the other rootstock treatments, the lowest pivot score and wines were assessed as having green and herbal with red fruit (rather than darker fruits). They also had higher levels of bunch-stem necrosis which is also generally associated with higher vigour.

110 Richter

110 Richter was grouped with 1103 Paulsen and 140 Ruggeri in the principal bi-plot analysis, but unlike these two rootstocks yield rankings relative to the other rootstocks increased from V15 to V16 and maintained in V19. The observations related to a vigour cycle are less clear with this rootstock, but may become evident in future seasons.

Merbein 5489 and Merbein 5512

M5489 and M5512 were planted as green pots in November 2010 and so they should be considered 2 years less developed than the other rootstock treatments. While they were the highest yielding rootstocks in V19 it must be remembered that 140 Ruggeri and 1103 Paulsen (and possibly 110 Richter) were possibly yield impacted by poor fruitfulness related to being out of balance. Based on field walk assessments (which were variable) there were many comments that did indicate that these two rootstocks produced relatively balanced vines.

There is enough evidence from the data to suggest that these two rootstocks should be considered for further commercial evaluation.

Ramsey

Somewhat surprisingly Ramsey was coupled with own roots in the principal biplot analysis and produced the lowest yield in V19 after producing the highest yield in V15. Vigour based on pruning weights and the canopy indices taken in V19 does not suggest that this rootstock was in a high vigour cycle as was suggested for 1103 Paulsen and 140 Ruggeri and so the general decline in yield ranking is difficult to explain. The only part explanation that can be given may be that the tap-root nature of Ramsey (high proportion of thick roots compared with feeder roots) coupled with the somewhat limited soil depth led to the inhibition of the yield and vigour potential that we normally associate with this rootstock.

Summary of Discussion

Any replicated trial is subject to limitations related to homogenous management which inherently biases towards the median rootstock. In this trial the choice of rootstocks selection has tended towards the extremes in terms of vigour and the water requirements. This has led to, at one end of the spectrum the higher vigour rootstocks possibly in a high vigour cycle (i.e. reducing yield due to shading of fruit zone) and the negative fruit composition results that accompany this high vigour cycle (Gladstones, 1992). At the other end of the spectrum the lower vigour rootstocks have not been able to develop and maintain healthy canopies and while this has been less detrimental to fruit and wine composition in the trial period, there could be ongoing vine health issues if this management regime were maintained.

If one were to take a narrow view of the trial results to date it would be possible to quickly dismiss some of the rootstocks in this trial as not suitable to the climatic conditions in the Coonawarra. But this would be premature. It is the original author's view that it is the management regime, coupled with the climatic conditions that led to the relatively poor performance of the higher vigour rootstocks in terms of their potential to produce a wine quality and style that is associated with Coonawarra.

This trial set-up is an excellent resource and holds enormous current and future value to the region and state in terms of better understanding and managing rootstocks.

It should be noted that this is one of two active rootstock trials across all 65 GI's in Australia and with some changes to the trial management away from homogeneous management of all rootstocks, it will ultimately fulfil one of the trial aims which is for Limestone Coast to be considered as a centre of excellence in rootstock knowledge.

Furthermore the purpose of any rootstock trial should be to not only determine those rootstocks that are well suited to a site or region but also (after extensive testing) identify those rootstocks that are currently not suited and thus potentially save a grower from investing up to $50,000/Ha in genetics that are inherently unsuitable.

As has been well reported the climate is changing and over time it would be expected that the performance of the rootstocks will change depending on the changing conditions. These observations on relative performance are only possible if you have this resource in the ground.

The only unresolvable limitation to the trial is missed opportunity of including lower and medium vigour rootstocks such as: 5C Teleki, 5BB Kober, Schwarzmann, 3309C and 101-14. As these rootstocks may have shown more promising results related to the production of wine quality and style that is associated with Coonawarra under the conditions experienced during the trial period.

The performance of new rootstock's M5489, M5512 and Börner is very promising and should provide impetus for further trials of new rootstocks including the C-Stocks from CSIRO and this could be coupled with some of the rootstocks mentioned in the previous paragraph in particular 3309C which is a very widely planted rootstock across a number of premium wine growing regions around the world. It must be stated however that the Merbein rootstocks have been hard to access by industry because the establishment of mothervines and subsequent distribution has been limited to two nurseries only. There have also been anecdotal reports of inconsistent strike rate in the nursery which has further limited uptake. The current model for the supply of these CSIRO developed rootstocks needs to be reviewed to allow for wider access by industry to ensure that there is broader uptake on the significant industry investment into the development of these rootstocks.

There are a number of rootstock breeding programmes around the world that are producing rootstocks that could add to the diversity of the region. A programme based out of UC Davis in California has developed 5 new rootstocks (GRN1-5) that while they were bred primarily for nematode resistance they contain some attributes suited to Coonawarra. In France there has been significant work looking at breeding rootstocks for adaption to dry soils. The barrier to the introduction to these rootstocks is in accessing licenses. Further research (outside the scope of this trial) of the potential of these rootstocks should be undertaking to determine their suitability and the cost-benefit of their potential access.

The original author has promoted the view over a number of years that consideration of the rootstock genetics does not end with selection, but rather that it is critical that we understand how best to manage the rootstock based on its genetics.

Next Steps: Value adding current data

It is recognised that further trial work be undertaken to better understand how to manage each of these rootstocks. However given that any further trial work would delay any release of information on rootstock performance by up to three years it is suggested that an interim 'Practical guide for managing rootstocks in the Limestone Coast' be developed based on the existing data from the trial coupled with observations of commercial performance of each of the rootstocks from vineyards within the region. This would ensure that there is an immediate outcome for growers in the region. It is also suggested that soil-pits be dug to understand how each rootstock has impacted root distribution and how this may help explain rootstock performance.

Next Steps: Future management of current trial

It is recommended that there should be further targeted trials in the randomised section to better understand how to exploit these rootstocks for the production of quality and a wine style that is suited to Coonawarra. The two major variables that would impact performance would be bud number per vine and irrigation applied. Given that it appears that the climate is going through a 'wetter' period, then irrigation applied may be hard to manipulate and so bud number per vine would be the variable that would be best investigated initially. Bud number manipulation may need to be combined with some alterations to canopy management.

Addendum

Regaining vine balance

As per recommendations from this trial report, pruning levels in winter 2020 were adjusted in attempt to get the out of balance rootstocks back into balance. Pruning levels were increased by 64% and 109% respectively on four of the nine replicates for the group of highest vigour rootstocks (1103P and 140R). Pruning levels were decreased by 20% on average on four of the nine replicates for the lowest vigour rootstocks (Börner, M6262 and own roots).

Viticultural measures will continue to be collected annually; however it is expected that outcomes from these pruning changes may take a number of years to be realised.

Virus testing

The rootstocks in the randomised section of the trial have not been virus tested to date. This testing is earmarked for the 2020/21 growing season. These results will be an important lens through which to consider the trial findings to date.

Rootstock root structure and volume

The next desired educational step from this trial is to demonstrate through the use of soil pits, the variability in root structure of the different rootstocks and the importance of this root morphology in the management of the rootstocks - particularly in terms of irrigation.

Trial future

Potential formats for the next stage of the trial were discussed at a partnership meeting in July 2020. Ideas to broaden the knowledge output from the trial were considered, including the potential addition of grower demonstration blocks planted with other rootstocks and Cabernet Sauvignon clones not currently part of the trial site.

Further discussions about the future model of the trial will be held in time, however, largely hinge on funding availability.

References

Becker, (1988) Börner: the first rootstock immune to all phylloxera biotypes. In the proceeding of the second International Cool Climate Viticulture and Oenology Symposium. Eds R.E. Smart et al. New Zealand Society for Viticulture and Oenology. Auckland, New Zealand.

Clingeleffer, P et al. (2011) Industry puts low-medium vigour rootstocks to the test. Wine and Viticulture Journal. May/June 2011.

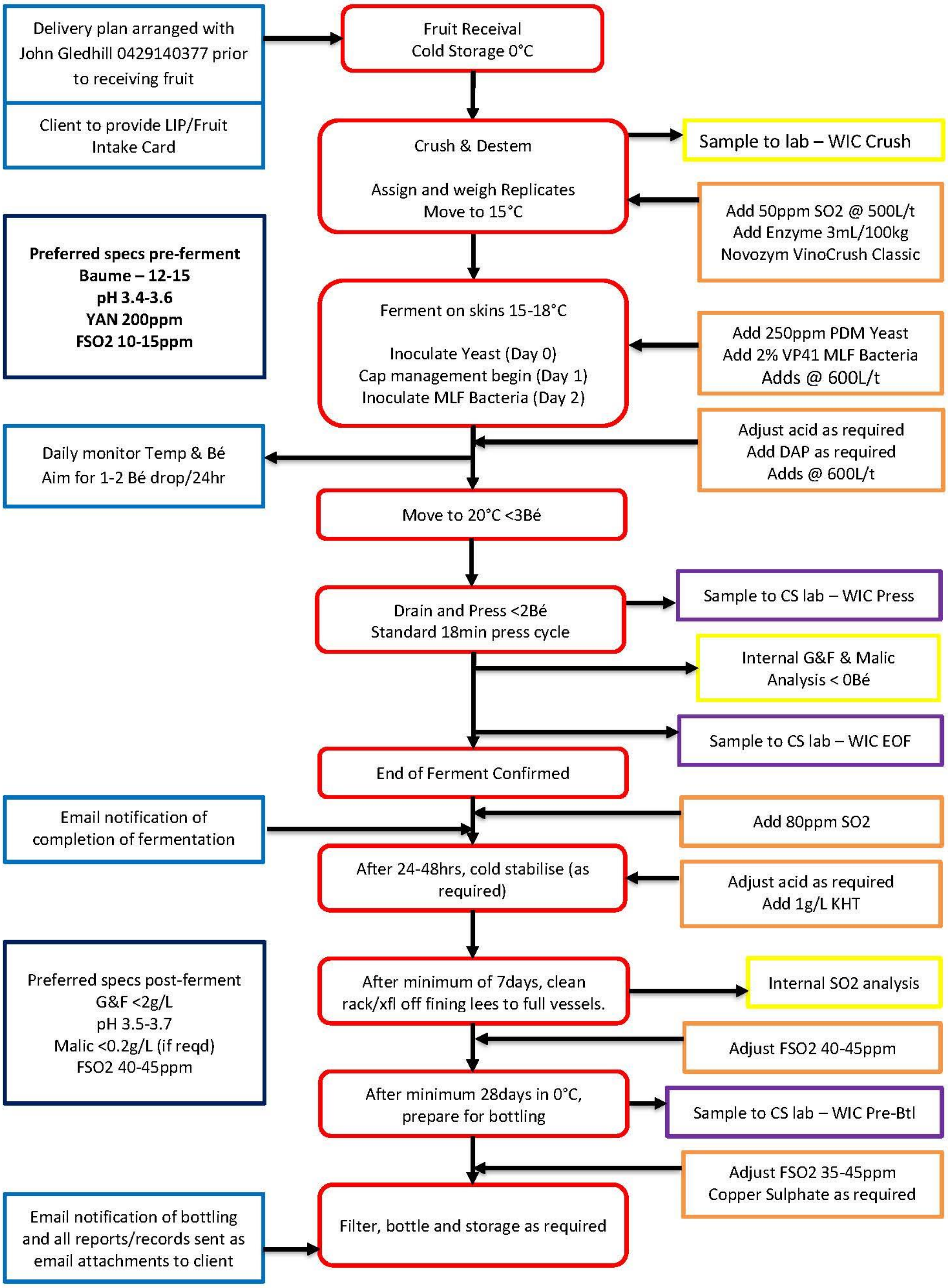
Dry, N (2007) Grapevine Rootstocks: Selection and Management for South Australian Vineyards. (Lythrum Press in association with Phylloxera and Grape Industry Board of South Australia: Adelaide).

Gladstones, J.S. (1992) 'Viticulture and Environment' (Winetitles: Adelaide)

Loder, H. (unpublished). The use of EM38 and precision viticulture techniques to improve water use efficiency (Coonawarra SA). file:///C:/Users/Signature/Downloads/using-EM38-to-improve-water-use-efficiency-trial-rep.pdf

Appendix 1 – AWRI Small Scale Red Fruit Winemaking Protocol

This is a Standard protocol used by WWS, and the Winemaker reserves the right to modify as necessary to achieve an optimal outcome.



Appendix 2 – AWRI Pivot tasting report