Ramsey and 110 Richter rootstocks perform well under water stress conditions in South Australia's Barossa Valley

By Catherine M. Kidman[1,2], Sandra Olarte Mantilla[1], Peter R. Dry[1,3], Michael G. McCarthy[4] and Cassandra Collins[1†]
[1] School of Agriculture, Food and Wine, University of Adelaide, Waite Research Institute, PMB 1, Glen Osmond, SA 5064
[2] Wynns Coonawarra Estate, Memorial Drive, Coonawarra, South Australia 5263.
[3] The Australian Wine Research Institute, Wine Innovation Cluster, Glen Osmond South Australia 5064
[4] South Australian Research and Development Institute, Research Road, Nuriootpa, South Australia 5355
[†] Corresponding author: Dr Cassandra Collins, phone +61 8 313 6813, email: cassandra.collins@adelaide.edu.au

INTRODUCTION

The use of grapevine rootstocks in South Australia has increased steadily over the past 30 years, yet rootstock use still only accounts for 20% of total plantings (Dry *et al.* 2007). Reproductive development may potentially be managed through the use of rootstocks (Candolfi-Vasconcelos and Castagnoli 1995, Cirami 1999, Whiting 2003, May 2004, Dry 2007). Although the effect of water deficit on reproductive development has been well documented (Matthews *et al.* 1987, Matthews and Anderson 1989, Poni *et al.* 1993), water use efficiency remains a critical issue for expansion and sustainability in Australian viticulture. Indeed, there is growing interest in the use of rootstocks to minimise the impact of possible future water shortages on production and wine quality, as may occur under future climate change.

This project was initiated by the Phylloxera and Grape Industry Board of South Australia in response to industry concern about water deficits during the 2006-2007 drought and was supported by the Grape and Wine Research and Development Corporation, now the Australian Grape and Wine Authority (AGWA).

The aims of this research were to examine the effect of a prolonged water deficit on grapevine reproduction and ascertain whether rootstocks could mitigate the effects of water deficit on the variety Shiraz – the most commonly planted red variety in Australia.

METHOD

Vines were grown on own roots (Shiraz BVRC30) or grafted to 110 Richter, 1103 Paulsen, 140 Ruggeri, 99 Richter, Ramsey or Schwarzmann (Table 1). Vines were either unirrigated, with irrigation lines bypassed for the duration of the three season experiment, or drip irrigated using irrigation sourced from either a bore or water from the Murray River using the Barossa Infrastructure Limited (BIL) scheme. Applied water was between 56mm/ha and 128mm/ha across the three seasons.

Table 1. Rootstock parentage and associated common names used in the trial at Nuriootpa, Barossa Valley, South Australia.

Rootstock parentage	Common name
Vitis, riparia x V. rupestris	Schwarzmann
V. berlandieri x V. rupestris	1103 Paulsen 110 Richter 99 Richter 140 Ruggeri
V. champinii	Ramsey

RESULTS AND DISCUSSION

2008-2009 season

Yield response was driven by a combination of bunch weight, bunch number and seeded berry number and was negatively correlated to seedless berries and millerandage—an abnormal condition of fruitset that results in a high proportion of seedless berries and live green ovules (LGOs) within the bunch (Collins and Dry 2009). Unirrigated 1103 Paulsen, Ramsey and 99 Richter had a high proportion of millerandage and seedless berries. Bunch weights and seeded berries were highest for own-roots Shiraz, both irrigated and unirrigated and 110 Richter unirrigated.

2009-2010 season

Low yields were due to low bunch and berry weights in unirrigated 1103 Paulsen, 140 Ruggeri, Schwarzmann, 110 Richter and 99 Richter compared with the other treatments. Bunch weight, yield and berry weight were positively correlated with each other while fruitset was negatively correlated with coulure—an abnormal condition of fruitset that results in a high proportion of flowers failing to develop or fertilise, also defined as excessive shedding of ovaries or young berries (May 2004, Collins and Dry 2009).

2010-2011 season

Fruitset was positively correlated with the number of seeded berries, cane number and berry number and negatively correlated with coulure and berry weight.

Overall, for Shiraz, rootstocks caused a higher incidence of coulure and a lower fruitset than own roots. Indeed, some varieties, for example Shiraz, are more susceptible to coulure than millerandage (Dry *et al.* 2010).

The absence of irrigation reduced yield by 25% in 2008-2009, 22% in 2009-2010 and 23% in 2010-2011 (Table 2, see page 44). Yield was lower in unirrigated treatments due to fewer bunches per vine, lower bunch and berry weights. Overall, zero irrigation reduced the number of LGOs and seedless berries and increased the proportion of seeded berries within a bunch. Rootstocks with the lowest yield across the three seasons were unirrigated 1103 Paulsen, Schwarzmann, 99 Richter and 140 Ruggeri (Table 2).

A cumulative effect of prolonged zero irrigation was observed through yield decline due to a reduction in bunch number and

Table 2. The effect of zero irrigation on yield across the three seasons of the trial based at Nuriootpa, Barossa Valley, South Australia.

Rootstock yield (kg/m cordon)		2008-2009	2009-2010	2010-2011
110 Richter	Full irrigation	3.04^{b}	3.2^{bc}	3.3^{cd}
	Zero irrigation	1.87^{dc}	2.6^{de}	3.1^{cde}
Ramsey	Full irrigation	1.64^{cde}	3.2^{bc}	4.2^{b}
	Zero irrigation	1.54^{def}	3.4^{ab}	3.5^{c}
Shiraz own roots	Full irrigation	4.17^{a}	3.6^{a}	3.5^{c}
	Zero irrigation	3.83^{a}	3.0^{c}	2.9^{ef}
Schwarzmann	Full irrigation	1.71^{cde}	3.6^{a}	3.3^{cde}
	Zero irrigation	1.47^{def}	2.4^{de}	2.0^{fg}
140 Ruggeri	Full irrigation	2.75^{b}	2.7^{d}	4.0^{a}
	Zero irrigation	1.60^{cde}	1.7^{f}	3.2^{cde}
99 Richter	Full irrigation	1.7^{cde}	3.3^{abc}	3.5^{c}
	Zero irrigation	1.1^{f}	2.3^{e}	3.0^{de}
1103 Paulsen	Full irrigation	1.99^{c}	2.3^{e}	3.3^{cd}
	Zero irrigation	1.35^{ef}	1.7^{f}	2.4^{fg}
***P*-value**		0.003	<.001	<.001

ANOVA of rootstock x irrigation interactions for the three seasons of analysis. Comparison of rootstock x irrigation interaction are given by $P<0.05$, $P<0.01$, $P<.001$ and not significant (n.s). Numbers within columns followed by the same letter are not significantly different from each other. For all rootstock x irrigation interactions, each value represents the mean of 21 replicate samples for each rootstock and irrigation combination.

weight. Unirrigated Ramsey rootstock was best able to mitigate the effects of prolonged drought and maintain yields comparable with irrigated Ramsey, with the exception of season 3. Overall, 1103 Paulsen unirrigated in every season was associated with the lowest yields, and has previously performed poorly in the absence of irrigation (McCarthy *et al.* 1997). Despite its poor performance, 1103 Paulsen continues to be ranked as drought tolerant for Australian conditions (Nicholas 1997, Dry 2007). Therefore, based on the results of this study, the classification of drought tolerance as defined by the ability to maintain yield (McCarthy *et al.* 1997) would include Ramsey and 110 Richter. In contrast, rootstocks susceptible to drought (i.e., suffered significant cumulative yield decline in the three year absence of irrigation) include 1103 Paulsen, own-roots Shiraz, 140 Ruggeri, 99 Richter and Schwarzmann. These outcomes have significant consequences for rootstock choice in grapegrowing regions of similar soil type. It is clear the soil type of the vineyard (Light Pass fine sandy loam A horizon overlying a red brown mottled clay B horizon (Northcote 1954)) influenced these drought tolerant rankings, in particular, the ability of 1103 Paulsen and 140 Ruggeri where elsewhere, on soil types such as coarse sand (Carbonneau 1985), and presumably with less root restrictions, these rootstocks were classified as drought tolerant.

The seasonal effect on yield outweighed many of the rootstock effects, which is consistent with findings of Keller *et al.* (2012). Unirrigated, own-rooted Shiraz was as drought tolerant as irrigated own-roots Shiraz for only the 2008-2009 season (season 1). Thereafter, a cumulative decline in yield was observed due to a reduction in bunch number and weight accompanied by reductions in FW:PW, which declined in each season. This infers that the unirrigated vines became progressively unbalanced in the absence of irrigation, producing more vegetative growth relative to reproductive growth due to a combination of reduced fruitfulness and bunch weight. Previous research has identified a negative carry over effect on productivity in the following season (Matthews and Anderson 1989, Petrie *et al.* 2004).

There was no significant effect of zero irrigation on fruitset in any of the three seasons. Matthews and Anderson (1989) also did not find an effect of irrigation on fruitset, which they attribute to an absence of water deficit at this phenological time point. Our results support a similar finding.

CONCLUSION

The absence of irrigation strongly influenced vine growth and performance. Although yields were reduced in all seasons due to zero irrigation, this was mainly due to a reduction in bunch number, bunch weight and berry weight rather than fruitset. In the absence of irrigation, Ramsey was the best

Figure 1. The effects of zero irrigation on the canopy of Shiraz unirrigated year 1 (A), Shiraz unirrigated year 2 (B) and 1103 Paulsen unirrigated in year 1 (C).

Figure 2. The comparison of Ramsey rootstock irrigated in year 2 (A) and unirrigated in year 2 (B), showing little differences between treatments.

performing rootstock and maintained values similar to irrigated treatments. In contrast, unirrigated 1103 Paulsen in every season was associated with the lowest yields. These findings may have significant consequences for rootstock choice in grapegrowing regions faced with future drought and water allocation issues.

For full results and details refer to Kidman *et al.* (2014).

REFERENCES

Candolfi-Vasconcelos, M.C. and Castagnoli, S. (1995) Choosing phylloxera resistant rootstocks for Oregon vineyards: The impact on vine performance and productivity. North West Berry and Grape Information Network http://owri.oregonstate.edu/sites/owri.org [accessed 29/12/2011]

Carbonneau, A. (1985) The early selection of grapevine rootstocks for resistance to drought conditions. American Journal of Enology and Viticulture 36:195-198.

Cirami, R.M. (1999) Guide for the selection of phylloxera resistant rootstocks. Phylloxera and Grape Industry Board of South Australia. Lythrum Press. Adelaide, South Australia.

Collins, C and Dry, P.R. (2009) Response of fruitset and other yield components to shoot topping and 2-chlorethyltrimethyl-ammonium chloride application. Australian Journal of Grape and Wine Research 15:256-267.

Dry, N. (2007) Grapevine rootstocks: Selection and management for South Australian vineyards. Phylloxera and Grape Industry Board of South Australia. Lythrum Press. Adelaide, South Australia.

Dry, P.R.; Longbottom, M.L.; Mcloughlin, S.; Johnson, T.E. and Collins, C. (2010) Classification of reproductive performance of 10 wine grape varieties. Australian Journal of Grape and Wine Research 16:47-55.

Keller, M.; Mills, L.J. and Harbertson, J.F. (2012) Rootstocks effects on deficit irrigated winegrapes in a dry climate: Vigour, yield formation and fruit ripening. American Journal of Enology and Viticulture 63:40-48.

Kidman, C.M.; Olarte Mantilla, S.; McCarthy, M.G.; Dry, P.R. and Collins, C. (2014) Effect of water stress on the reproductive performance of Shiraz (*Vitis vinifera* L.) grafted to rootstocks American Journal of Enology and Viticulture 65:60-72.

Lebon, G.; Wojnaroweiz, G.; Holzapfel, B.; Vaillant-Gaveau, N. and Clemént, C. (2008) Sugars and flowering in the grapevine (*Vitis vinifera* L.) Journal of Experimental Botany 59, 2565-2578.

Matthews, M.A and M.M. Anderson (1989) Reproductive development in the grapevine (*Vitis vinifera* L.): Responses to seasonal water deficits. American Journal of Enology and Viticulture 40:52-60.

Matthews, M.A.; Anderson, M.M. and Schultz, H.R. (1987) Phenologic and growth response to early and late season water deficits in Cabernet Franc. Vitis 29:147-160.

May, P. (2004) Flowering and fruitset in grapevines. Lythrum Press. Adelaide, South Australia.

McCarthy, M.G, Cirami R.M and Furkaliev D.G (1997) Rootstock response of Shiraz (*Vitis vinifera* L.) grapevines to dry and drip irrigated conditions. Australian Journal of Grape and Wine Research 3:95-98.

Nicholas, P.R. (1997) Rootstock characteristics. The Australian Grapegrower and Winemaker Vol. 400:37.

Northcote, K.H. (1954) Soils and land use in the Barossa district, South Australia. Zone 1. The Nuriootpa Area. CSIRO publishing, Melbourne, Australia.

Petrie, P.R.; Cooley, N.M. and Clingeleffer, P.R. (2004) The effect of post veraison water deficit on yield components and maturation of irrigated Shiraz (*Vitis vinifera* L.) in the current and following season. Australian Journal of Grape and Wine Research 10:203-215.

Poni, S.; Lasko, A.N.; Turner, J.R. and Melious, R.E. (1993) The effects of pre- and post- veraison water stress on growth and physiology of potted Pinot Noir grapevines at varying crop levels. Vitis 32:207-214.

Whiting, J. (2003) Selection of grapevine rootstocks and clones for greater Victoria. DPI Victoria, Australia.

WVJ