Murray Valley Winegrowers' Inc

Australian Government
Grape and Wine Research and Development Corporation

Preventing Delayed Ripening in Winegrapes



FINAL REPORT to

GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

Project Number: **RT 03/31-5**

Principal Investigator: **Susan Byrne & Liz M^{c}Guire**

Research Organisation: **Murray Valley Winegrowers' Inc.**

Date: **6/12/05**

Executive Summary

Winegrape growers' in warm regions have long struggled to ripen fruit early with the expectations of better quality. This study however shows that vineyard variability and seasonal weather conditions make it hard to determine specific causes for early ripening fruit or preventing the delayed ripening of fruit.

Scholefield Robinson Mildura were contracted to prepare and deliver a report which

1. Investigated scientific literature reviewing factors that affected fruit ripening,
2. Conduct interviews with industry representatives to determine the sentiment about whether early ripening fruit was of better quality and thus produced better wine and the,
3. Analysis of benchmarking data

The scientific literature reported that excessive watering can delay harvest and that the rate of ripening is largely dependent on the number of actively photosynthesising leaves. The scientific literature however could not give any definitive answers with many papers reporting opposing results.

The interviews resulted in half the respondents indicating they believed that early ripening fruit improved quality however respondents had little evidence to prove these beliefs.

The analysis of benchmarking data tied in with a Scholefield Robinson Mildura study to develop an indicator of winegrape quality. In the benchmarking data analysed it was shown that there was an "inconsistent relationship between harvest date and fruit quality" for a six year period.

The results of this project illustrated the strong influence that vineyard variability and seasonal weather conditions can have on the development and ripening of fruit and the potential quality of that fruit.

Readers of this report and the attached report prepared by Scholefield Robinson Mildura should not conclude that the production of top quality fruit ripening early or delayed is not affected by the quality of their production techniques and should be left to chance but rather that some aspects of winegrape production require prediction and subsequent action.

Background

An obstacle for growing quality winegrapes in the Murray Valley is the excessive heat fruit is exposed to late in the ripening season. This is a key message that growers' are receiving from their buyers, "early ripening fruit is of better quality".

Excessive heat can have a number of negative influences on fruit quality, these include:

- Sunburn
- Loss of colour (anthocynins) in red winegrapes
- Loss of malic acid
- Loss of aromas and flavour
- Greater exposure to pests and diseases

One method of overcoming this obstacle is to harvest early and therefore minimise the exposure the fruit has to excessive heat. To harvest early, fruit needs to ripen (that is target Baume is reached) early in the season. Scientific literature has shown certain management techniques can result in early ripening or prevent delayed ripening.

Murray Valley Winegrape growers' felt this concept needed to be explored for its validity and for any subsequent management techniques that could be implemented to positively influence the timing of fruit harvest.

This project has strong regional significance; it is a concept that is topical amongst growers', yet there is no supporting data or resources explaining the "hows and whys". Growers have communicated their sense of frustration with this concept, as there is no specific information to define the advantages of early ripening fruit and means of achieving it. This project aims to provide the answers.

Objectives

- Review articles both published and unpublished on topics associated with the timing of fruit maturation and the affect it has on winegrape and wine quality.

- Undertake discussions with both scientists and winemakers for their opinion(s) on the relationship between harvest dates and the affect on fruit and wine quality.

- Undertake discussions with scientists and winemakers for their opinion(s) on why early harvested fruit produces better quality fruit and wine.

- Produce a report which critically analyses the results from the literature review and discussions with the scientific community and winemakers.

- Produce recommendations on information that needs to be communicated to growers on this topic.

Method

This project was contracted to Scholefield Robinson Mildura with the outcomes to be distributed to growers by means of an article in the Murray Valley Winegrowers' newsletter "The Grapevine".

Results / Discussion

Scholefield Robinson Mildura compiled a report (see Appendix 1) containing the objectives of this project. The report investigated many potential contributing factors relating to early ripening of fruit and the potential for better quality, unfortunately many of these factors gave conflicting results in alternative years providing non-conclusive answers to the how's and why's of early ripening fruit.

The most conclusive answers reported was that:

1. Growers in warm irrigated regions such as the Murray Valley should avoid prolonging fruit maturity which can be caused by irrigation scheduling and,

2. Fruit maturity timing despite the fruit load is affected by the number of actively photosynthesizing leaves and the amount of light penetrating the canopy.

Below is a listing of summary points that illustrates the variety of factors that influence early ripening as reported by the scientific literature. For full explanation of these points please refer to the Scholefield Robinson report (Appendix 1)

1. Early harvested Shiraz fruit can be of high quality.
2. Early ripening Shiraz fruit has a positive relationship with colour. The age of Shiraz vines can influence the date of maturity. Yield of Shiraz does not affect harvest date.
3. Early harvested Shiraz fruit has 25% better colour and Glycosyl-Glucose. Late harvesting Shiraz fruit can achieve good colour and Glycosyl-Glucose if the canopy is large, but not dense, allowing light to reach bunches and the majority of leaves.
4. Cabernet Sauvignon fruit maturation can be delayed by high crop loads or excessive irrigation. Delayed harvest due to high crop loads does not affect final wine quality, however if excessive irrigation is the cause of delayed harvest this will negatively impact wine quality.
5. Moderate yielding Shiraz vines (18-22t/Ha) that are not overly vigorous can mature fruit without delay and with good colour. Harvest date is an unreliable measurement, as it is not always a decision based on maturity; other important influences are winery logistics and weather.
6. Heat stress will reduce sugar accumulation and therefore delay fruit maturation.
7. Excessive irrigation delays fruit maturation and there is a mixed response to water stress. Timing of irrigation will influence fruit maturation; however this influence varies between winegrape varieties.
8. A vine with a moderate yield can ripen fruit adequately (or without delay) as long as it has sufficient actively photosynthesizing leaves; this information can be gleaned from effective leaf area to fruit weight ratios or crop loads.
9. Excessive shading of leaves (leaf layering) can cause a delay in fruit maturation.
10. Over watering vines will delay maturation, moderate water stress vines will advance maturation.
11. Fruit maturation of Shiraz is dependant on berry shrivel.
12. In hot regions, delayed harvest will increase exposure to excessive temperatures, which for Shiraz fruit will reduce colour.
13. Delayed harvest for Cabernet Sauvignon and Grenache may expose fruit to excessive sunlight, causing fruit temperature to reach levels that result in a decrease in colour and acid and an elevated pH.
14. Prolonged exposure of Merlot fruit to temperatures over 35^{o}C will reduce colour and acidity.
15. A water deficit for Shiraz between fruit set and veraison (otherwise known as RDI), followed with moderate irrigation during veraison will ensure fruit maturation is not delayed.
16. High crop loads delay the harvest date for Shiraz, but this relationship does not exist for Cabernet Sauvignon or Chardonnay.
17. Cluster thinning on overcropping Shiraz vines can ripen fruit early and increase anthocyanins, phenolics and acid levels.
18. Rootstocks can influence harvest date. Varying weather conditions in each growing season makes it difficult to pin point a single management or

environmental variable that consistently influences fruit quality and or fruit maturation.

19. Mechanical thinning offers the potential to regulate yield, advance harvest and improve fruit and wine quality characteristics of Cabernet Sauvignon in the warm irrigated grape growing regions.
20. Early harvested fruit in some years produces better quality fruit. Heavy crop loads tend to delay maturity of Shiraz.

The executive summary of the report complied by Scholefield Robinson Mildura was printed in the Murray Valley Winegrowers' newsletter "The Grapevine" (see Appendix 2) to report the project's findings.

The report complied by Scholefield Robinson Mildura has also been listed on the Murray Valley Winegrowers' Inc webpage www.murrayvalleywinegrapes.com.au

Outcomes / Conclusion

The topic of early ripening fruit, it's how's and why's and whether it produces better quality is one that has frustrated winegrape growers' in the Murray Valley. This report however indicates that there is no simple solution with many factors influencing the early ripening or preventing the delayed ripening of fruit, many of which are related to vineyard variability and seasonal weather conditions.

Acknowledgements are made to GWRDC for funding provided for this project.

APPENDIX 1

Scholefield Robinson
HORTICULTURAL SERVICES

Early Ripening in Wine Grapes

Prepared for : **Murray Valley Winegrowers' Inc**

By : **Susan Saris & Angela McGill**

Date : **June 2005**

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EXECUTIVE SUMMARY

Scholefield Robinson Mildura (SRM) was contracted by the Murray Valley Winegrowers' Inc. to address the question of whether early ripening fruit results in better quality fruit/wine.

This review considers the opinions of local winemakers and scientists via an industry questionnaire, seeks evidence through scientific papers using a literature review as well as drawing on data gathered by SRM as part of their quality benchmarking group over the last six years.

Literature review:

- Most of the research that examines whether early ripening fruit produces better quality is on Shiraz, for which there does seem to be a relationship between harvest date and quality. However, this is not a clear cut rule as there are many examples in the literature of later ripening Shiraz also producing good quality fruit.
- Numerous research papers support the finding that excessive irrigation delays harvest and is detrimental to fruit/wine quality.
- There is no direct relationship between yield levels and fruit maturation (harvest date). While there are many studies that have shown an increase in ^{o}Brix in response to reduced yields, other research has reported no consistent response of yield reduction to sugar production. A better measurement of a vine's ability to ripen fruit adequately and without delay is crop load; the ratio of actively photosynthesizing leaves to fruit weight.
- Any correlations between fruit quality and harvest date need to consider whether the fruit was harvested at its optimal ripeness or whether factors such as seasonal weather conditions or the grape intake logistics of the winery influenced the harvest date.
- Growers in warm irrigated regions such as the Murray Valley should probably be more focused on avoiding prolonged fruit maturation. Red winegrape varieties that are exposed to prolonged high vineyard temperatures may suffer a reduction in berry anthocyanin levels. A drawn out harvest will also decrease fruit acid and increase pH.

Industry data:

- SRM's project, "Development of a wine grape quality index" has for the last six years demonstrated an inconsistent relationship between harvest date and fruit quality. There was a negative correlation of QIN and harvest date in 2003 for Shiraz and Cabernet Sauvignon and in 2005 for Merlot. Such inconsistencies can be explained by the influence of weather conditions on fruit quality in each growing season

Interviews:

- Half of the respondents to the industry questionnaire believed that early ripening fruit improved wine quality due to better acid/sugar balance, higher colour and improved flavour profile.
- There was little objective evidence provided by respondents to support these assertions.

INTRODUCTION

Scholefield Robinson Mildura (SRM) was contracted by the Murray Valley Winegrowers' Inc. to address the question of whether early ripening fruit results in better quality fruit/wine.

To begin to understand this concept one needs to define 'early ripening fruit'. For the purpose of this paper early ripening fruit is fruit that has been harvested at an optimal maturity at a date earlier than average, for a particular region or locality within that region. The definition of optimal maturity will vary depending upon the style of wine being made, the working definition of quality, variety, rootstock, site, interaction of rootstock and site, seasonal specific factors, viticultural practices, and downstream processing events and goals (Bisson 2001). In the winemaking industry it is known that wine quality is directly correlated with achieving optimal maturity.

This review considers the opinions of local winemakers and scientists via an industry questionnaire, seeks evidence through scientific papers using a literature review as well as drawing on data gathered by SRM as part of their quality benchmarking group over the last six years.

Please note the tables and figures included in this report are numbered according to the original research papers they are extracted from.

METHODOLOGY

The following components were used to develop this review:

1. Literature review: Research papers were sourced from the WAITE Library database at the University of Adelaide, Charles Sturt University database via the internet, Department of Primary Industries Library, and CSIRO Library.
2. Industry data: Six years of historic data has been collected by SRM for the Wine Grape Quality Index project. The information has been collected from vineyards in the Sunraysia/Riverland regions and it attempts to link fruit quality measurements with a range of other factors including harvest date.
3. Interviews: a structured interview was conducted with regional scientist and winery personnel. This provided them with an opportunity to offer their opinion on the subject and provide historical data on the possible affect timing of fruit maturation has on quality.

1. LITERATURE REVIEW

The literature review is a critique of articles from books and journals which either touch on or directly explore the issue of harvest date and its affect on fruit/wine quality. The review also explores the inputs and management techniques that can influence harvest date (or fruit maturation).

Note the term crop load is used often in the literature, however the definition is not always the same, it can mean the following:

- Fruit weight to pruning weight ratio
- Leaf area to fruit weight ratio
- Fruit weight per meter of vine

Section A : Literature Pertaining to the Relationship Between Harvest Date And Fruit/Wine Quality

Ripening Grapes to Specification: Effect of Yield on Colour Development of Shiraz Grapes in the Riverina

Holzapfel B., Rogiers S., Degaris K, & Small G. – Riverina 1999

Aim:

To present results on the relationship between yield, berry colour and sugar levels for Shiraz.

Procedure:

The study was conducted on own-rooted Shiraz in the Murrumbidgee Irrigation Area (MIA) in NSW. Twelve vineyards were sampled weekly from early January to harvest. Measurements included berry weight, total soluble solids (°Brix), colour, yield and harvest date.

Results:

The figure below shows the different rates of °Brix maturation for the twelve surveyed vineyards.

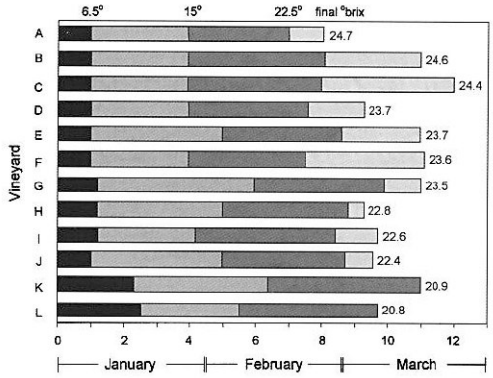
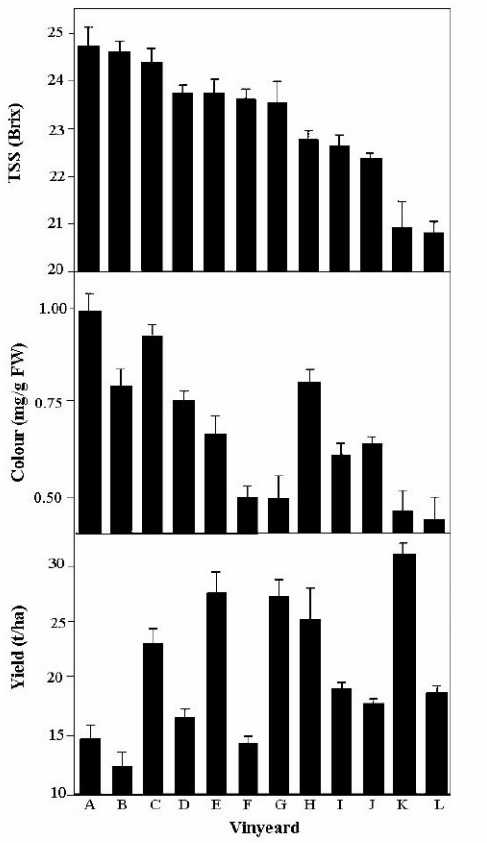


Figure 2. Time (weeks) from 6.5° (veraison) to reach 15°, 22.5° and final brix levels (harvest) in Shiraz grapes in the MIA in 1998.

The figure below illustrates the widely varying colour, yield and °Brix levels of the different vineyards at harvest.

Figure 3 : TSS, berry colour and yield in 12 vineyards at harvest in Shiraz (MIA) in 1998 (vertical bars represent standard errors of the man, n=10)



Discussion:

The authors note that harvest stretched over one month and that 'vineyards harvested later in the season did not necessarily produce better quality fruit'. Vineyard A, which produced fruit with good colour (see Figure 3), took the shortest time to reach veraison and maturity (22.5 °Brix) and was harvested earlier than the other vineyards (see figure 2, page 3). Vineyards K and L, on the other hand produced fruit with low °Brix and poor colour; took the longest to reach veraison and did not ripen fully . The authors go on to state "This supports the perception that fruit which are slow to ripen through the season, and perhaps have longer cumulative exposure to the sun, are not high in quality". An analysis on the correlation between colour and harvest date would have been worth while to further support this statement. While this article does not necessarily support the concept that early ripened fruit is better quality it does support the idea that early harvested fruit can be of high quality and vice versa.

Take home message: Early harvested Shiraz fruit can be of high quality.

Demonstration of Association Between Grape Colour and Wine Quality

Gorman K. – Riverland 2001

Aim:

Establish quality segmentation via objective criteria which is accepted by grape producers and grape purchases.

Procedure:

A survey was conducted on Shiraz vineyards in the Riverland. Data collected included yield, end use (scale 1-5), colour, baume, berry weight, harvest baume, harvest date and year the vine was planted.

Results:

	Colour	End Use	Yield
Harvest Date	$r^2 = 0.18$ r = -0.42 p = <0.001	$r^2 = 0.073$ r = - 0.27 p = 0.12	$r^2 = 0.0361$ r = 0.19 p = 0.16

Harvest date had a correlation with colour; the earlier picked fruit had better colour scores. There was no relationship between harvest date and end use or yield. A strong correlation existed for harvest date and age of the vines; older vines were picked earlier (data was not shown in the report).

Take home message: Early ripening Shiraz fruit has a positive relationship with colour. The age of Shiraz vines can influence the date of maturity. Yield of Shiraz does not affect harvest date.

Canopy Architecture – Implications for Shiraz Grown in a Hot, Arid Climate

Botting D., Dry P. & Iland P. – Riverland 1996

Aim:

To determine the importance of a number of canopy characteristics for fruit composition and quality and to determine the range of the concentration of glycosylated secondary metabolites of grapes produced in hot arid regions.

Procedure:

Canopy architecture and grape composition of 25 Shiraz vineyards in Riverland were studied. Canopy leaf area, canopy density, canopy volume, bunch exposure and the ratio of leaf area to fruit weight were determined. Grapes were sampled throughout the latter half of the growing season from early February to mid-April. Measurements included total soluble solids (°Brix), pH, titratable acidity (TA), colour and Glycosyl-Glucose (G-G)

Results and Discussion:

Concentrations of colour and G-G in grapes were negatively correlated with the time taken for individual vines to reach the target harvest maturity of 23 ± 0.5 °Brix (see Figure 2 below), which in turn was positively correlated with yield. Grapes at 23.0 ± 0.5 °Brix harvested from vines ripening late in the season generally had about 25% lower levels of colour and G-G than those from earlier ripening vines (see Table 3 below). There was a spread of seven weeks between the earliest and latest ripening vineyard of the 25 vineyards studied.

Figure 2 : Relationship between the number of days after January 1 to reach 23± 0.5. °Brix and the concentrations of colour and G-G Shiraz, Riverland, 1995. (Correlation coefficient 'r' for colour = 0.4957 and for G-G = 0.6233. Both are significant at the 1.0% level)

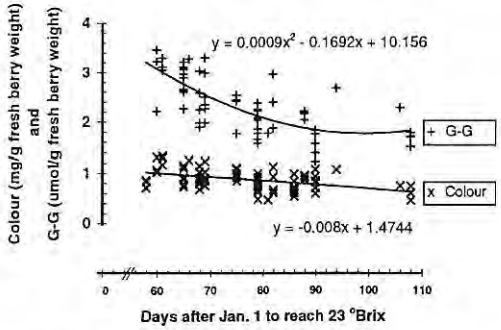


Table 3. The differences in the concentrations of colour and Glycosyl - Glucose of grapes harvested early and late in the season (all at 23.0 ±0.5 °Brix), selected Shiraz vineyards, Riverland, 1995.

	February 28 (day 59)	March 31 (day 91)	% diff
Colour (mg /g fresh berry weight)	1.00	0.75	25
Glycosyl - Glucose (µmol/g fresh berry weight)	3.30	2.20	33

Derived from relationships: Colour = -0.008 + 1.4744 and GG = 0.0009 x days - 0.1692 x days + 10.156

There were two notable exceptions to the above trends, namely vineyards D and K; both vineyards attained relatively high levels of colour and G-G despite moderate to high yields (see

Table 4 and Figure 4, below). Vineyard K, in particular attained high levels of colour and G-G late in the season at a sugar concentration lower than the target harvest °Brix. Compared with the range of values for most vineyards in this study both of these vineyards had a moderate to high bunch exposure and a moderate canopy leaf area. Vineyard K had one of the lowest canopy densities and the largest canopy volume. The author makes inferences that though early ripening fruit and lower yielding vines generally scores higher colour and G-G, there are exceptions to this general rule. These exceptions relate to the architecture of the vine, a large vine that is not dense, has the capacity to produce good quality fruit (defined by colour and G-G), regardless of yield or time of harvest. If we look at the description of vines in vineyard K we can see that it had a large framework, but was moderately vigorous and this was achieved with light pruning. It is also interesting to note that this was an old vine.

Table 4. Yield and vegetative components and canopy characteristics, selected Shiraz vineyards, Riverland, 1995.

Selected Vineyard:	Description
B	low to mod. vigour, narrow trellis, light to nil pruning
D	moderate vigour, wide tee trellis, light to nil pruning
E	high vigour, wide tee trellis, mod. heavy pruning
H	high vigour, single wire trellis, young vines
K	moderate vigour, old vines, large framework, light pruning
N	high vigour rootstock, light to nil pruning

	Vineyard					
	B	D	E	H	K	N
Yield components						
Yield (t/ha)	15	24	29	30	28	43
Bunches/'vine'	117	391	233	228	388	520
Bunch weight (g)	81	47	88	97	56	54
Berry weight (g)	0.9	0.7	1.0	1.2	0.8	1.0
Canopy components						
Shoot length (m)	65	67	100	125	63	74
Leaf area (m^2/'vine')	9.2	18.2	25.0	18.6	18.0	26.6
Leaf area to fruit weight ratio	12.9	12.1	12.5	9.0	8.5	9.7
Canopy volume (m^3/'vine')	2.2	4.9	5.3	4.7	7.9	4.0
Canopy density (LA/Vol)	4.1	3.8	4.7	4.0	2.3	6.6
Bunch exposure (µmol/m^2/s)	453	293	167	169	351	115

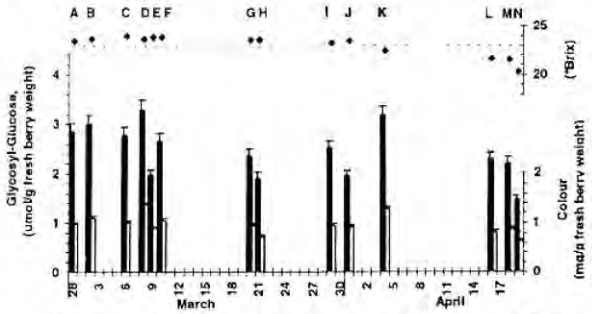


Fig. 4. Concentrations of sugar, colour and G-G for selected Shiraz vineyards at their respective harvest dates, Riverland, 1995.

Take home message: Early harvested Shiraz fruit has 25% better colour and Glycosyl-Glucose. Late harvesting Shiraz fruit can achieve good colour and Glycosyl-Glucose if the canopy is large, but not dense, allowing light to reach bunches and the majority of leaves.

Section B : Literature Pertaining to Inputs and Management Techniques Influencing Harvest Date

Effect of Irrigation and Crop Level on Growth, Yield and Wine Quality of Cabernet Sauvignon.

Bravdo B., Hepner C., Loinger C., Cohen S. & Tabacman H. – hills of Adulam region in Israel 1985

Aim:

To measure the effect different irrigation and crop load levels have on wine quality of Cabernet Sauvignon.

Procedure:

One of the concepts the researchers examined was the effect crop load (defined as grape yield/pruning weight ratio) had on sugar accumulation and hence harvest date. The researchers created different crop loads by thinning fruit on the vine after bloom. A low crop load was achieved by leaving 20 bunches on the vine, a moderate crop load was achieved by leaving 40 bunches on the vine and a high crop load was achieved with 60-70 bunches per vine. Crop load values varied between 3-10.

The researchers also examined the effect different irrigation scheduling had on sugar accumulation. They applied excessive and restricted water amounts.

Wines were made from fruit that had been harvested from vines with different crop loads and irrigation amounts.

Discussion:

It was found sugar accumulation was delayed when the vine had a high crop load. However a low crop load did not always guarantee an early harvest; if it was combined with excessive irrigation this caused the greatest delay in harvest date.

In this trial, harvest date was always delayed by excessive irrigation. Over-watering during veraison stimulates the vine to divert energy away from fruit maturation into vegetative growth, the consequence being a prolonged fruit ripening period. Excessive vegetative growth may also overshade the ripening fruit aggravating the problem of delayed maturation.

It was found that fruit that came from high crop loads did not adversely affect wine quality, however fruit that came from vines that were excessively irrigated tended to be the lowest in quality.

Take home message: Cabernet Sauvignon fruit maturation can be delayed by high crop loads or excessive irrigation. Delayed harvest due to high crop loads does not affect final wine quality, however if excessive irrigation is the cause of delayed harvest this will negatively impact wine quality.

Ripening Grapes to Specification: Identifying Manageable Factors Determining Grape Composition & Quality Through Carbohydrate Sink-source Relationships

Holzapfel B. & Rogiers S – Riverina 2001

Aim:

The objective of this project was to investigate the impact of delayed ripening on berry composition.

Procedure:

The study was conducted on own rooted Shiraz in the Murrumbidgee irrigation area (MIA) in NSW. Ten vineyards were surveyed for two seasons (1998/99 and 1999/2000), each vineyard was sampled weekly from early January (veraison) to harvest. Fruit from the vineyards was measured for berry weight, °Brix, colour, phenolics, pH, titratable acidity, yield, pruning weights and harvest date.

Discussion:

The authors note that it was difficult to compare harvest date to quality in this survey, as harvest date was not always based on fruit maturity alone, see table below.

Table 1.2 Water and N application rates, harvest date and reason for harvesting as part of two-year Riverina survey

	1998/1999				1999/2000			
Site	ML/ha	Kg N/Ha	Harvest date	Decision*	ML/ha	Kg N/Ha	Harvest date	Decision
S3	6.0	55.2	26-Feb	O/B	?	0	8-Mar	Wi/We
S5	?	21.0	7-Mar	B	?	67	14-Mar	Wi
S6	8.5	127.5	16-Mar	Wi/B	6.0	0	20-Mar	We
S7	6.0	103.5	8-Mar	Wi/B	?	23	12-Mar	Wi
S9	?	32.2	5-Mar	Wi	?	0	6-Mar	B
S10	?	36.0	17-Mar	?	2.0	22	14-Mar	We
S11	2.5	68.0	18-Mar	Wi/B/We/Pi	1.5	51	22-Mar	We
S12	?	211.3	25-Mar	O	7.5	135	22-Mar	?
S13	1.0	18.7	5-Mar	Wi	?	34	3-Mar	?
S15	5.0	130.0	8-Mar	O/We	?	130	20-Mar	Wi

* B = Brix, O = own, Pi = pickers, Wi = winery, We = weather

In the first season the harvest decision was mainly dictated by berry ripeness and the winery schedule, while in the second year it was the weather and the winery schedule.

A management technique often used cited as a method for preventing delayed ripening and increasing quality is to reduce yield, however the survey from this report challenges this idea. The results from this survey found that moderate yielding vineyards can mature grapes properly (without delayed maturation), with good berry colour, and that low yielding vineyards do not necessarily produce fruit that has adequately ripened or with good colour. Sites S6, S7 & S9 are examples that support this theory; in both seasons they achieved reasonable yields (18-22t/Ha – see tables on page 9) and were not late maturing. These sites were achieving reasonable yields by means of high shoot number and more bunches per shoot rather than vigour. On the other hand site 10 is an example of a vineyard that was low yielding each season, yet did not mature early.

Table 1.3 Riverina Shiraz vineyard productivity and berry composition during the 1998/99 season (standard errors of the means are shown in small type).

Site	Brix	TA g/L	pH	Berry wt. g	colour mg/Fw	Yield T/ha	Pruning wt. T/ha
S3	24.7	3.57	3.57	1.29	0.99	14.8	3.0
	0.42	0.10	0.10	0.03	0.05	1.21	0.18
S5	22.4	3.13	3.97	1.37	0.64	17.8	1.7
	0.14	0.08	0.01	0.03	0.02	0.45	0.09
S6	23.7	2.89	4.24	1.30	0.66	27.6	2.7
	0.32	0.08	0.03	0.05	0.05	1.91	0.13
S7	22.6	3.14	4.01	1.24	0.61	19.1	2.0
	0.25	0.10	0.03	0.03	0.03	0.66	0.11
S9	22.8	2.80	4.15	1.02	0.80	25.3	2.3
	0.20	0.06	0.02	0.02	0.03	2.79	0.22
S10	24.6	2.79	4.22	0.83	0.79	12.4	1.4
	0.27	0.07	0.04	0.04	0.04	1.32	0.15
S11	23.5	3.13	4.19	1.27	0.49	27.3	3.2
	0.46	0.16	0.04	0.03	0.06	1.48	0.17
S12	24.4	4.02	4.08	1.03	0.92	23.1	2.4
	0.31	0.28	0.03	0.03	0.03	1.35	0.11
S13	23.7	2.68	4.19	1.01	0.75	16.7	2.0
	0.18	0.11	0.04	0.03	0.03	0.80	0.11
S15	20.8	4.89	3.71	1.32	0.44	18.8	2.7
	0.25	0.11	0.02	0.03	0.06	0.66	0.11

The table below has an error in the heading, it should read: Riverina Shiraz vineyard productivity and berry composition during the **1999/2000** season.

Table 1.4 Riverina Shiraz vineyard productivity and berry composition during the 1998/99 season (standard errors of the means are shown in small type).

Site	Brix	TA g/L	pH	Berry wt. g	colour mg/Fw	Yield T/ha	Pruning wt. T/ha
S3	22.28	3.77	3.99	1.11	1.01	20.91	2.81
	0.09	0.04	0.01	0.02	0.03	0.89	0.15
S5	21.71	3.74	4.08	1.42	0.76	12.52	2.62
	0.12	0.07	0.01	0.04	0.02	0.45	0.11
S6	21.11	3.80	3.91	1.44	0.95	20.73	3.53
	0.16	0.19	0.03	0.07	0.05	1.48	0.20
S7	23.43	3.80	3.90	1.08	1.00	22.00	2.95
	0.18	0.06	0.02	0.04	0.03	1.22	0.14
S9	23.68	3.90	4.16	1.26	1.07	18.94	3.07
	0.10	0.08	0.02	0.03	0.03	2.18	0.32
S10	22.35	2.60	4.15	1.22	1.02	8.74	2.31
	0.28	0.10	0.03	0.07	0.04	1.04	0.22
S11	21.33	3.78	4.00	1.50	0.86	27.58	3.32
	0.19	0.07	0.02	0.06	0.04	0.89	0.11
S12	21.43	3.57	4.02	1.12	1.18	27.62	3.71
	0.11	0.05	0.01	0.02	0.03	1.34	0.14
S13	23.97	3.24	4.30	0.94	1.10	18.91	2.66
	0.26	0.06	0.02	0.03	0.03	1.19	0.11
S15	18.74	4.69	3.89	1.41	0.48	20.31	4.40
	0.27	0.13	0.01	0.03	0.03	1.22	0.15

Take home message: Moderate yielding Shiraz vines (18-22t/Ha) that are not overly vigorous can mature fruit without delay and with good colour. Harvest date is an unreliable measurement, as it is not always a decision based on maturity; other important influences are winery logistics and weather.

Environmental and Management Practices Affecting Grape Composition and Wine Quality – A Review

Jackson D. & Lombard P. – 1993

2A. Temperature. (i) Effect on Soluble Solids

Although warmer temperatures will normally hasten growth and ripening, there is an upper limit above which assimilation is reduced. Alleweldt (1) found optimum net assimilation rate by photosynthesis to be at 25^{0}C, and the work of Kliewer (24) suggests photosynthesis is 90% to 100% efficient between 18^{o}C and 33^{o}C, declining markedly as temperatures move above or below those levels. Heat stress markedly reduces stomatal conductance and glucose content of the berry (39).

Take home message: Heat stress will reduce sugar accumulation and therefore delay fruit maturation.

2B. Irrigation

Matthews and Anderson (29) showed that although water stress can increase phenols in juice and skin and anthocyanins in skin and reduce malate and increase proline, it had no effect on onset of veraison or duration of ripening.

In reviewing irrigation effects, Smart and Coombe (44) noted that excessive irrigation slows ripening, increases yield partially by berry enlargement, elevates juice pH and reduces anthocyanins from shading due to continuous and excessive shoot growth. In contrast, water stress enhances early ripening but reduces yield, berry weight, and malic acid from excessive exposure.

Other research (6,32) has demonstrated that excess [irrigation] will normally reduce sugar, but moderate irrigation, especially in dry years, will increase it.

While the amount of water stress may be important it appears that so too, is it's timing. Alleweldt and Ruehl (2) showed under controlled conditions in a greenhouse, plentiful water at the beginning of the experiment increased yield and lowered sugar; if applied towards the end of berry development, it did not affect yield but increased sugar. Becker and Zimmerman (3) also confirmed increased yield and lower sugars at maturity by application of adequate moisture before veraison. Müller-Thurgau was a common variety used in both sets of pot experiments, but variety differences may be important in such responses. Riesling was much less sensitive to drought conditions than Müller-Thurgau.

Take home message: Excessive irrigation delays fruit maturation and there is a mixed response to water stress. Timing of irrigation will influence fruit maturation; however this influence varies between winegrape varieties.

4. Effects of Yield

The author cites publications that illustrate that high yields delay maturity (8,48). However the author also notes that 'Although many studies do show an increase in soluble solids (sugar) if yields are reduced, others report no consistent responses' (13,35). He believes such irregularities can be explained by effective leaf area to fruit ratios. Effective leaves are those that are actively photosynthesizing (i.e. are not shaded or stressed) and are contributing sugar to ripening fruit. This ratio gives us an indication of whether there are enough photosynthesising leaves on a vine

for the amount of fruit the vine carries. The ratio below which sugar level starts to decline is usually reported to be between 7 and 10 cm^2/g (22,23,25,27,30,43). Increasing the ratio above this figure has minimal effect on the Baume. If we use the leaf area to fruit weight ratio as a measurement instead of yield, we are able to explain how vines with moderate yields are able to ripen fruit without delay; these vines will have the appropriate number of actively photosynthesizing leaves to support a moderate yielding vine.

It is noted in this article that some authors use the concept of crop load instead of leaf area per unit of fruit weight. Crop load in this article is defined as the yield/dormant pruning weight; this equates inversely and approximately to leaf area per unit fruit weight and is often used as it is easier to measure. The author notes caution when using this measurement as it is not able to take into account the canopy design, i.e. are the majority of the leaves on the vines actively photosynthesizing? Or are there shaded/stressed leaves, which would not be contributing to ripening of the fruit?

Take home message: A vine with a moderate yield can ripen fruit adequately (or without delay) as long as it has sufficient actively photosynthesizing leaves; this information can be gleaned from effective leaf area to fruit weight ratios or crop loads.

5C Effects of Light and Shade

Shade whether natural or artificial, nearly always reduces sugar levels and usually increases acidity on any one date, a response which is normally interpreted as delayed maturity. (26,33,37,45,46). It appears that this is probably more a consequence of leaf shading than berry shading (11,33).

Take home message: Excessive shading of leaves (leaf layering) can cause a delay in fruit maturation.

Water Relations of Grapevines – Effects on Time of Ripening and Sugar Concentration

Smart R. & Coombe B. - 1983

Improved water status almost invariably increases yield and delays ripening (see table below). For example, Spayd and Morris (41) have shown that light pruning, irrigation, and, to a lesser extent, nitrogen fertilization all increased yield for Concord grapevines and that these different cultural practices all delayed fruit ripening. Similarly, Freeman et al. (14) found that both light pruning and irrigation delayed ripening, but that, for similar vine yields, irrigation delayed ripening more than light pruning.

Hardie (16) noted that although sugar concentration was increased by water stress, sugar content per berry or vine was reduced. A significant effect of water stress on berry volume was therefore implicated: advances in fruit ripening induced by water stress are associated with reductions in berry weight (shrivelling). However a note of caution from the authors that severe water stress causes defoliation and reduces leaf photosynthetic rate, and under these conditions fruit ripening is delayed (17).

Well-watered grapevines typically develop very leafy canopies, to the extent that they may be photosynthetically inefficient. Water stressed vines, on the other hand, with fewer and smaller leaves, allowed direct and diffuse sunlight to penetrate deeper into the canopy. Vines that were watered enough to allow vegetative growth to continue late into the growing season always resulted in delayed maturity (12,34,47).

Variety	Yield (non-irrigated) (tons ha^{-1})	Change due to Irrigation (%)					Reference[a]
		Yield	Pruning weight	Sugar content	Acidity	pH	
Chenin Blanc	12.4	131	137	−3	9	6	1
Shiraz	7.1	122	110	—	54 to −8	4	2
Muscat of Alexandria	14.5	80	—	2	6	—	3
Shiraz	12.4	76	104	—	—	—	4
Muscat Hamburg	10.5	73	—	9	−3	—	5
Cabernet Sauvignon	7.0	51	42	2	16	−7	6
Chenin Blanc	17.7	43	35	−1	26	−3	7
Italian Riesling	6.0	42	20	−2	2	—	8
Pinot Gris	5.8	40	—	7	19	—	5
Carignan	—	36	46	−1	13	—	9
Concord	9.6	24	50	−5	1	—	10
Carignan	—	3	4	−3	13	—	9
Chasselas (sand)	—	26	—	<1	13	—	11
Chasselas (clay)	—	−17	—	<1	−4	—	11

[a] References: 1, Vaadia and Kasimatis (1961); 2, Freeman *et al.* (1979); 3, Hendrickson and Veihmeyer (1951); 4, Smart *et al.* (1974); 5, Alexandrescu *et al.* (1966b); 6, Neja *et al.* (1977b); 7, Van Zyl and Weber (1977); 8, Alexandrescu *et al.* (1966a); 9, Branas (1967); 10, Spayd and Morris (1978); 11, A. Jacquinet (private communication).

Take home message: Over watering vines will delay maturation, moderate water stress vines will advance maturation.

Dynamics Of Grape Berry Growth And Physiology Of Ripening

Coombe B. & McCarthy M. - 2000

At a time around 90 days after flowering, when fruit is 18-20°Brix, Shiraz berries begin to decrease in weight; this is due to blockage of phloem transport into the berries, which would normally deliver water and sugar to the fruit. Though sugar transport into the berry is blocked, the Brix continues to rise, this is due to berries shrivelling, or dehydrating, concentrating the sugar in the berry.

Logically Shiraz that is picked early has accumulated a substantial amount sugar prior to the blockage of the phloem and is not overly reliant on shrivel or dehydration for sugar maturation. Perhaps when Shiraz is reliant on shrivel for maturation this is determinantal to fruit/wine quality?

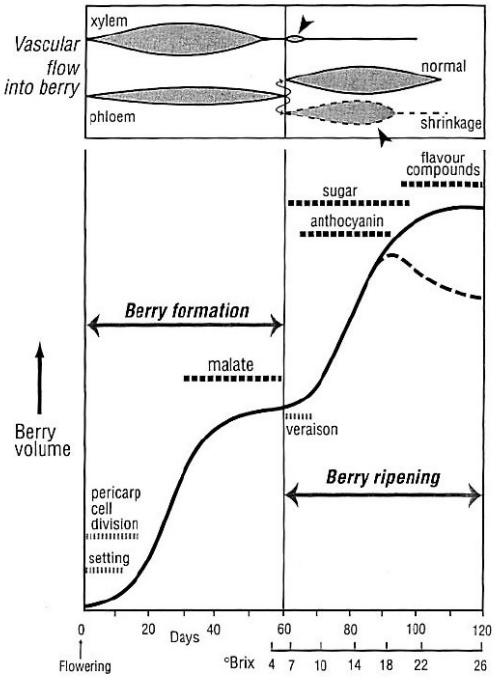


Figure 5. Notional diagrams showing, at top, estimates of rates of vascular flow into berries, partitioned between xylem and phloem, their sum matching the rates of water input as shown by the berry volume growth curves below of Muscat (solid lines) and Shiraz (dashed lines). The berry volume is an idealised curve against days after flowering and juice °Brix and shows the berry shrinkage and phloem blockage of Shiraz starting at about 18-20°Brix; the arrow-heads at top signify the timing of the proposed impedance of xylem flow (in all varieties) and of phloem flow in berries that shrink. Three successive but overlapping phases of solute accumulation are indicated—malate, sugar and flavour compounds—each sequence occurring in both varieties. Based on data in Coombe (1987, 1992), Coombe and McCarthy (1997), McCarthy (1997b) and McCarthy and Coombe (1999).

Take home message: Fruit maturation of Shiraz is dependant on berry shrivel.

Canopy Microclimate and Berry Composition : The Effect of Bunch Exposure on the Phenolic Composition of *vitis vinifera* l cv. Shiraz Grape Berries

Haselgrove, L., Botting, D., van Heeswijck, R., Hoj, P.B., Dry, P.R., Ford, C. & Iland, P.G.- Riverland 2000

Aim:

To examine the effect bunch exposure has on Shiraz berries grown in a hot climate.

Procedure:

Experiment 1 – Two levels of bunch exposure were imposed, fully shaded and fully exposed. The temperatures for both treatments were monitored. Anthocyanin levels were measured four times between veraison and 46 days after veraison.

Experiment 2 – Temperature and anthocyanins were measured from bunches positioned in the centre of vine and the north side of the vine (exposed to afternoon sun).

Results:

Figure 1 : The change in anthocyanins per berry (relative absorbance units per berry) for berries sampled from the shaded (■) and exposed (□) treatments at various sampling dates during ripening of Shiraz grapes (Experiment 1). Each value represents the mean of four replicates and vertical bars indicate the standard error of the mean for each value.

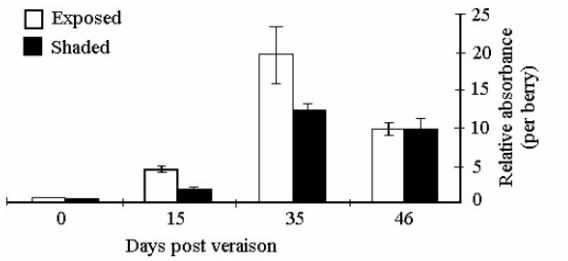


Figure 3 : Variation over time in temperature of ripening berries in bunches situated in the centre of the canopy is shown as A. The difference in temperature of berries in bunches located in the 'north' side compared with those in the 'centre' is shown as B (Experiment 2)

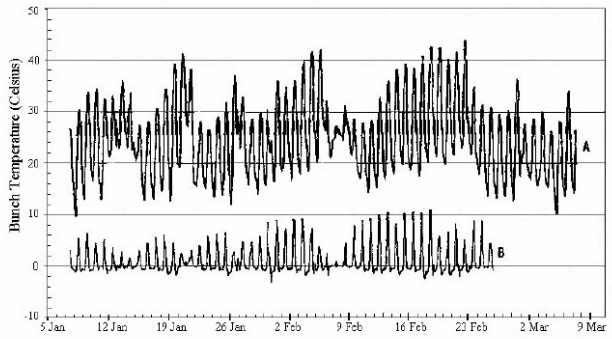


Table 3 : Comparison of Brix, average berry weight and phenolic composition of berries from bunches in either the 'centre' or 'north' positions of the canopy, at a similar berry maturity (Experiment 2)

	Centre (shaded)	North (exposed)	Significance[1]
°Brix	24	24	ns
Berry weight	0.86	0.71	ns
Total anthocyanins (mg per berry)	0.95	0.50	***
Total anthocyanins (mg per g berry weight)	1.11	0.70	***
% malvidin-3-glucoside	44	51	*
% malvidin-3-(acetyl)-glucoside	26	26	ns
% malvidin-3-(p-coumaryl)-glucoside	30	23	*
Quercetin-3-glucoside (mg/berry)	0.056	0.127	***
Quercetin-3-glucoside (mg per g berry weight)	0.065	0.178	***

1. * and *** indicate that treatment means are significantly different at the $P < 0.05$ and the $P < 0.001$ level, respectively; ns indicates no significant difference.

Discussion:

Anthocyanin metabolism responds to changes in both light and temperature conditions. In conditions where bunches are heavily shaded, as in Experiment 1, it is likely that light is a limiting factor in the accumulation of anthocyanins during the early stages of ripening. In Experiment 2, it seems that while berries on both the 'centre' and 'north' bunches are receiving adequate light for anthocyanin production, the temperature conditions of the 'north' bunches may be a limiting factor, see Figure 3. In this site it is likely that the berry temperature is sufficiently high in the 'north' bunches (generally being over 35°C during the afternoon period) to inhibit anthocyanin synthesis and/or increase anthocyanin degradation for a considerable period during the day.

Management practices that create a canopy architecture where bunches receive sufficient light for anthocyanin synthesis, but where berries are protected from excessive berry heating, a condition often described as 'dappled light', would seem appropriate for the production of fruit with optimal levels of anthocyanins for vines grown in hot climates.

In Experiment 1 there was a decline in total anthocyanin content of berries during the later stage of ripening (see figure one). This trend was also apparent in the development of anthocyanins in berries from 'centre' and 'north' bunches of Experiment 2 (data not shown). This phenomenon of anthocyanin decline over time has been reported previously (40, 38). The significance of this feature is that if fruit is left too long on the vine, this can result in a loss of anthocyanins.

Take home message: In hot regions, delayed harvest will increase exposure to excessive temperatures, which for Shiraz fruit will reduce colour.

Sunlight Exposure and Temperature Effects on Berry Growth and Composition of Cabernet Sauvignon and Grenache in the Central San Joaquin Valley of California

Bergqvist J., Dokoozlian N., & Ebisuda N. – San Joaquin Valley of California 2001

Aim:

To examine the effects of sunlight exposure on the berry growth and composition of Cabernet Sauvignon and Grenache.

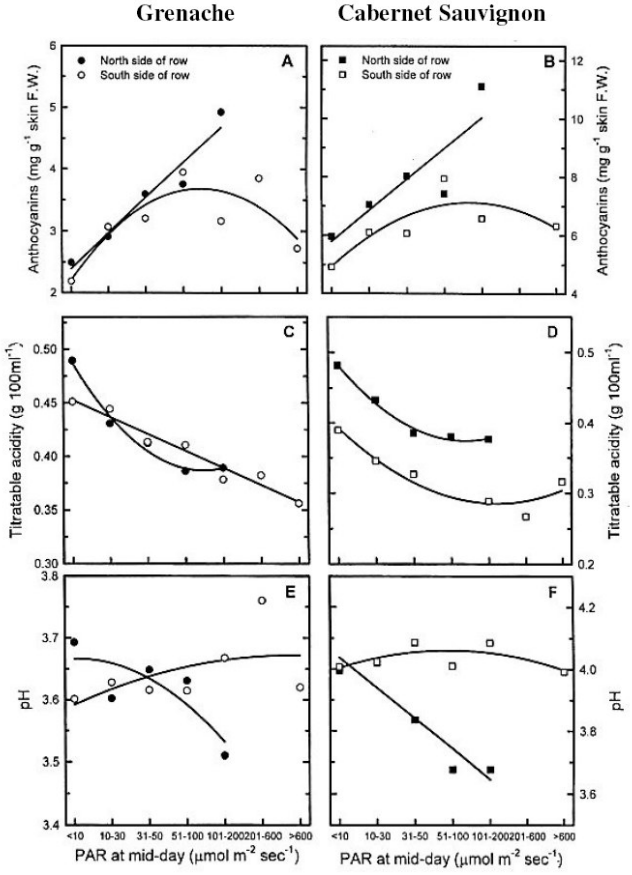
Procedure:

The trial was conducted at the San Joaquin Valley on 8 year old own-rooted Cabernet Sauvignon and Grenache. The treatments of interest are:

(1) North side of the row - shaded in the afternoon (2) South side of the row – exposed to sunlight in the afternoon.

Results/Discussion:

Sun exposure had a negative influence on berry colour. While increased exposure to light generally stimulates anthocyanin accumulation in grape berries, high temperatures accompanying excessive sun light exposure inhibits colour formation.



The x axis for the graphs on page 17, is the measurement of sunlight radiation, increasing from left to right. The north side of the row (■) was shaded in the afternoon and the south side of the row (□) was exposed to sunlight in the afternoon. Mid-day berry temperature was generally 3 to 4°C greater for fruit clusters on the south side of the canopy compared to clusters on the north. As fruit temperature increased, due to increased sunlight exposure, colour and acidity decreased and pH increased.

Take home message: Delayed harvest for Cabernet Sauvignon and Grenache may expose fruit to excessive sunlight, causing fruit temperature to reach levels that result in a decrease in colour and acid and an elevated pH.

Separation of Sunlight and Temperature Effects on the Composition of Vitis Vinifera cv. Merlot Berries

Spayd, S.E., Tarara, J.M., Mee, D.L. & Ferguson, J.C. – Washington 2002

Aim:

To examine how sunlight exposure and increased temperature affects the composition of Merlot grapes.

Procedure:

Experiment 1: The four treatments of interest are:

Treatment Number	Type of Treatment	Affect Treatment Had on Fruit
1	Sun-exposed **(Sun-control)**	Fruit from this treatment was subjected to high UV and high temperatures
2	Shaded by shoots **(Shade-control)**	Fruit from this treatment was subjected to low UV and low temperatures
3	Shaded & heated to the temperature of sun-exposed clusters in treatment 1 **(Shade-heated)**	Fruit from this treatment was subjected to low UV and high temperatures.
4	Sun-exposed & chilled to the temperature of shaded clusters in treatment 2 **(Sun-cooled)**	Fruit from this treatment was subjected to high UV and low temperatures

Experiment 2:

Treatment Number	Type of Treatment
1	Exposed to direct sunlight on the east side of the canopy **East-exposed**
2	Exposed to direct sunlight on the west side of the canopy **West-exposed**
3	Shaded from sunlight on the east die of the canopy. **East-shaded**
4	Shaded from sunlight on the west side of the canopy **West-shaded**

Results/Discussion

Experiment 1:

The table below shows the results for the accumulated heat loads for each treatment. The results show that the sun-cooled fruit was accumulating similar heat loads to the shade control and the shade heated clusters were accumulating similar heat loads to the sun control. The table also illustrates the difference in solar radiation between sun exposed fruit and shaded fruit.

	Growing degree days (°C) in 1999		Growing degree days (°C) in 2000	
Treatments	*Bunch closure to harvest*	*Solar radiation (MJ/m^2)*	*Bunch closure to harvest*	*Solar radiation (MJ/m^2)*
Sun control	495	549	586	360
Shade control	439	129	521	69
Shade heated	505		602	
Sun cooled	442		519	

Temperature accumulation by the fruit clusters in the trial were expressed as growing degree days, (adding mean temperature for each day over a growing season). Cumulative exposure to solar radiation was determined from tube solarimeters placed in the fruiting zone

At harvest the fruit from the different treatments was measured for a range of parameters, which included pH, titratable acidity (TA) and anthocyanins. The results were as follows:

Table 3 : Effect of sun exposure and temperature on Merlot berry composition at harvest 1999 to 2000

Treatments in 1999	*Berry mass (g/berry)*	*Soluble Solids (%)*	*TA (%)*	*pH*	*Total colour (AU/mL)*
Sun control	1.00a	23.2c	0.60c	3.59bc	16.2b
Shade control	1.13a	23.8b	0.73a	3.56c	16.9b
Shade heated	1.06a	23.2c	0.59c	3.68a	12.5c
Sun cooled	1.02a	24.4a	0.62bc	3.63b	21.7a
Treatments in 2000					
Sun control	1.32a	22.3ab	0.15cd	3.78bc	11.6b
Shade control	1.33a	21.2c	0.76a	3.73bc	10.7b
Shade heated	1.27a	21.6bc	0.46d	3.89a	10.9b
Sun cooled	1.15a	23.0a	0.59bc	3.70c	15.2a

In both years, shade-heated and sun-control had the lowest TA, while shade-control had the highest TA. The results illustrate that high temperature (in this trial measured as Growing Degree Days) lowered fruit acidity.

Shade-control, shade-heated, and sun-control clusters had the lowest colour results, while sunlit-cooled clusters had the most colour for both years of the trial. This trend also existed when berry size was taken into account. These results suggest that maximum colour production in Merlot occurs when there is some exposure to UV light, coupled with moderate temperatures.

Experiment 2:

The table below shows the number of hours Merlot berry temperatures were: >30°C, >35°C and >40°C

Table 7 : Number of hours Merlot berry temperature exceeded selected temperature thresholds from bunch closure to harvest, 1999 to 2000.

	Threshold temperature (°C)		
1999	*Number of hours at>30°C*	*Number of hours at >35°C*	*Number of hours at>40°C*
East-exposed	148.2	3.2	0
East-shaded	53.2	0	0
West-exposed	181.4	73.6	2.8
West-shaded	83	0	0
2000			
East-exposed	114.6	7.6	0
East-shaded	45	2.6	0
West-exposed	149.6	67.4	2.6
West-shaded	61	2.6	0

In both years, west-exposed clusters were above 35°C for more than 65hr between bunch closure and harvest, while clusters in other three locations were above 35°C for no more than 7.6hr. Of the four locations, only west-exposed clusters reached temperatures greater than 40°C in either year.

Table 8 : Effects cluster position had on berry mass and composition of Merlot, 1999 to 2000

	Berry mass (g/berry)	*Soluble Solids (%)*	*TA (%)*	*pH*	*Total colour (AU/mL)*
Treatments in 1999					
East-exposed	1.27a	23.0ab	0.17b	3.5b	18.4a
East-shaded	1.29a	23.3a	0.81ab	3.49b	16.7ab
West-exposed	1.15b	22.5b	0.59c	3.62a	11.6c
West-shaded	1.14b	22.9ab	0.82a	3.46b	14.7b
Treatments in 2000					
East-exposed	1.47a	23.2a	0.61b	3.61b	18a
Shaded	1.35a	22.4b	0.76a	3.55c	13.2b
West-exposed	1.30a	2.7ab	0.52c	3.71a	13.7b

In 1999, west-exposed clusters had the lowest colour and in the second year it was again low. The results showed that for Merlot fruit, the number of hours above 35°C was associated with a net loss of anthocyanins. However, number of hours above 30°C was positively related to anthocyanin concentrations. Excessively high temperatures are detrimental to anthocyanin accumulation in the skins, but some degree of heat is needed for synthesis. The authors observe critical temperature for net anthocyanin accumulation in Merlot berry skins may lay between 30 and 35°C.

Titratable acidity was highest in shaded fruit, followed by east-exposed and the lowest in west-exposed fruit. West-exposed fruit had the highest pH of the four cluster locations. Again high temperatures are determinantal to preserving acidity in the fruit.

Take home message: Prolonged exposure of Merlot fruit to temperatures over 35°C will reduce colour and acidity.

Irrigation Influences On Berry Composition And Shoot Growth

McCarthy M. – Waikerie 1996

Aim:

To determine the effect of the timing of water stress on berry growth and composition.

Procedure:

The experiment comprised of seven irrigated treatments and an unirrigated treatment with the timing of water deficit being determined by anthesis (flowering), veraison and harvest date in each season. During each of the water deficit periods, which lasted approximately four to eight weeks, irrigations were withheld. See Figure 2 below for a schematic representation of the irrigation withholding periods.

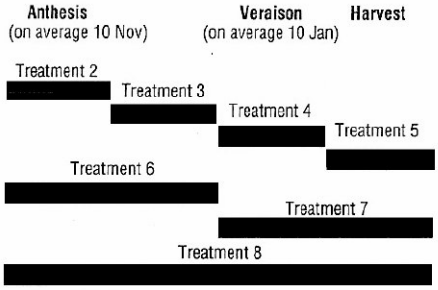


Figure 2. Schematic representation of the irrigation withholding periods (shaded). Treatment 1 was fully irrigated for the whole season, Trt 8 was unirrigated from the commencement of the experiment in 1991.

Results:

Table 1 : Susceptibility of Shiraz berries to water deficit during four growth phases

Period of Water Deficit	Berry Susceptibility Factor
Post anthesis	2.4×10^{-2}
Pre-veraison	1.06×10^{-2}
Post veraison	0.89×10^{-2}
Pre-harvest	-0.18×10^{-2}

Discussion:

Water deficits after anthesis (flowering) to veraison caused the greatest reduction in berry size this was maintained through to harvest. The author encourages the use of such a water deficit to create small berries and to control vegetative growth during this period. However McCarthy warns that water deficit should be avoided after veraison to ensure rapid ripening. Excess irrigation at this time should also be avoided to ensure shoot growth does not recur and cause delayed ripening.

Take home message: A water deficit for Shiraz between fruit set and veraison (otherwise known as RDI), followed with moderate irrigation during veraison will ensure fruit maturation is not delayed.

Crop Development, Crop Estimation, Crop Control to Secure Quality and Production of Major Wine Grape Varieties: A National Approach

Clingeleffer P. – Sunraysia 2001

Chapter 7.9 Ripening and Quality Studies

Aim:

To examine the rates of ripening across a number of varieties and experimental sites within Sunraysia, with different cropping levels.

Procedure:

After veraison grape samples were collected every 10-14 days. Measurements included, bunch weight & number, berry weight and °Brix. A week prior to harvest, grape samples were also taken for pH and titratable acidity (TA) measurements.

Results:

An inverse relationship with crop load (kg fruit/m vine) and the rate of ripening occurred with Shiraz (r^2=0.5), although this was not seen in Chardonnay or Cabernet Sauvignon.

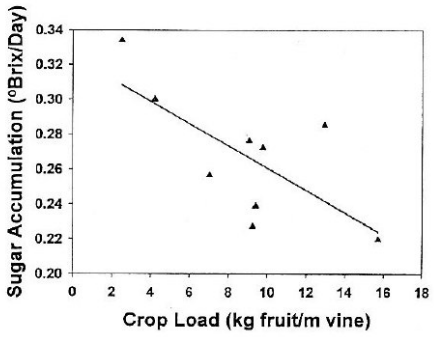


Figure 7.9.1 The relationship between crop load (kg fruit per metre of cordon) and the rate of sugar accumulation (°Brix per day) in the variety Shiraz grown in Sunraysia during the 1998/99 season.

Take home message: High crop loads delay the harvest date for Shiraz, but this relationship does not exist for Cabernet Sauvignon or Chardonnay.

Crop Development, Crop Estimation, Crop Control to Secure Quality and Production of Major Wine Grape Varieties: A National Approach

Clingeleffer P. – Sunraysia 2001

Chapter 7.8 Crop Control through Mechanical Thinning

Aim:

To investigate the influence of mechanical thinning Shiraz, on fruit maturation, yield and some key parameters of wine quality.

Procedure:

The Shiraz block used was high yielding (~40t/ha) and in the past had always had problems reaching baume and colour specifications. During the 1999/2000 growing season a harvester was used to mechanically thin approximately 30-35% of the fruit. This took place in early December when the berries were approximately pea size.

Results:

Thinning caused an estimated 35% reduction in yield; the control vines yielded around 19 kg/vine whereas the mechanically thinned were approximately 14kg/vine.

The thinned treatment had a delayed veraison date; however it must have ripened at a much higher rate as it reached maturity before the unthinned fruit. Fruit from the mechanically thinned treatments reached 23 ^{o}Brix on the 8th March, while the control/unthinned treatment did not reach 23 ^{o}Brix until the 26th of March.

The thinned fruit had a significantly higher level of titratable acidity and lower pH than the control. Also, the anthocyanin and phenolic levels were significantly higher (approximately 30%) in the thinned treatment.

Figure 7.8.5 (a) average titratable acidity (g/L) for control and thinned vines; (b) average juice pH for control and thinned vines.

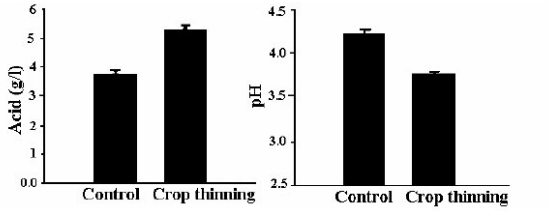
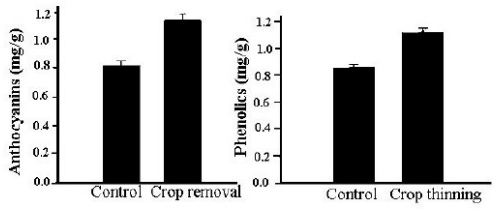


Figure 7.8.6 (a) average anthocyanins (mg/g) for control and thinned vines; (b)average phenolics (mg/g) for control and thinned vines.



Take home message: Cluster thinning on overcropping Shiraz vines can ripen fruit early and increase anthocyanins, phenolics and acid levels.

Matching Rootstocks and Scion Combinations in Sunraysia

Krstic M. & Hannah R – Sunraysia 2003

Aim:

To better understand the interaction of rootstock and scion on yield and quality parameters of wine grapes in the Sunraysia. The varieties included: Chardonnay, Cabernet Sauvignon and Shiraz.

Procedure:

In 1996 three trial sites were established with grafted vines. A number of assessments were conducted throughout the 4 growing seasons. These included: maturity and berry weight testing after veraison, wine quality analysis: °Brix, pH, titratable acidity, colour, phenolics, chloride, sodium, potassium and nitrogen.

Results:

In this trial all scion varieties grafted to 101-14 produced early ripening fruit, while retaining good yields and quality parameters suitable for winemaking. Shiraz grafted to 101-14 was able to ripen 6 weeks early than other rootstocks. The early ripening fruit had lower pH and higher titratable acidity, except in Cabernet Sauvignon.

The authors make a note in their conclusion of the report that during the life of the project, each year was climatically different making it difficult to pin point a single factor that influences fruit quality when it is not in a controlled environment (i.e. many variables were at work).

> *'However, because of the atypical weather it has been difficult to draw consistent conclusions. Analysis of the 1999/2000 weather data revealed the 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. Analysis of the 2002/2003 weather data revealed that this was a very dry season. However, above average rainfall occurred in December and February. The 2002/2003 season was generally considered a cool growing season. These climatic considerations need to be taken in to consideration when interpreting the results obtained in this study.'*

Take home message: Rootstocks can influence harvest date. Varying weather conditions in each growing season makes it difficult to pin point a single management or environmental variable that consistently influences fruit quality and or fruit maturation.

Mechanical Thinning to Stabilise Yield and Improve Grape Maturity and Colour

Petrie, P., Clingeleffer, P. & Krstic, M. – Sunraysia 2003

Aim:

To examine if mechanical thinning, as a management tool, can be used to regulate yield and improve fruit quality.

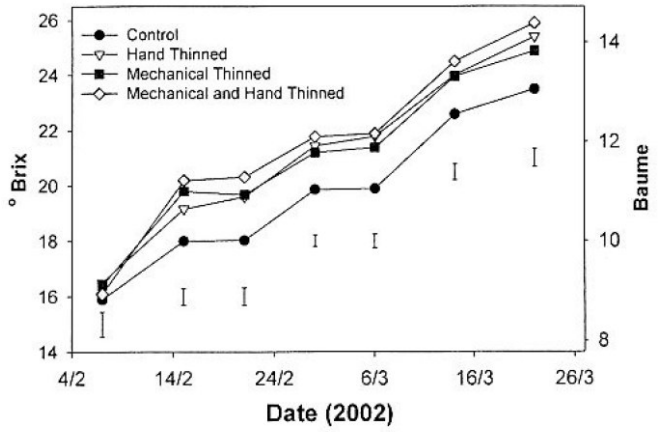
Procedure:

Four treatments were used: 1) control, 2) mechanically-thinned vines, 3) hand-thinned vines from a similar position in the canopy to the mechanical-thinned vines, 4) mechanically-thinned vines that were then hand thinned to remove the damaged bunches.

Samples were taken at weekly intervals to determine berry weight, anthocyanin and phenolic concentrations, °Brix, pH, and titratable acidity.

Results:

The difference in sugar content between the thinned and the unthinned vines became apparent on the second sampling date and was maintained through until harvest. See graph below.



Mechanical, but not hand-thinned, treatments caused a significant improvement in anthocyanin concentration in the fruit. This was probably caused by the difference in berry size between mechanical thinning and hand thinning treatments. Small berries increase the skin to pulp (surface area to volume) ratio of the fruit and as most of the anthocyanins are contained in the skin, this has a direct impact on the anthocyanin content of the wine must.

Take home message: Mechanical thinning offers the potential to regulate yield, advance harvest and improve fruit and wine quality characteristics of Cabernet Sauvignon in the warm irrigated grape growing regions.

2. INDUSTRY DATA

Development of a Wine Grape Quality Index

Swinburn G. – Mildura 2000-2005

Aim:

To devise an approach to quantifying wine grape quality that relies on objective measurements. A Quality Indicator Number (QIN) is calculated by combining berry anthocyanins, °Brix, pH, acid and other relevant data into a single index that reflects the quality of the fruit.

Procedure:

Measurements are made across a number of vineyard sites of Shiraz, Merlot and Cabernet Sauvginon in the Sunraysia and Riverland region. Measurements include: canopy score, leaf area, berry anthocyanin, phenolics, °Brix, pH, titratable acidity, harvest date, tonnes/ha, crop load (defined as kg of fuit/m^2 of canopy area), bunch number, bunch weight, berry number, berry weight, juice yield. The measurements are statistically analysed and used to develop a model that weights relevant measurements, to produce a single indicator number (QIN) which reflects the quality of the fruit.

Results:

2001 Data

No relationship between QIN and harvest date for any of the varieties. There was a positive correlation between crop load and harvest dates for Shiraz (r=0.59). Therefore the later the fruit is harvested in Shiraz vines the higher the crop loads.

2002 Data

No relationships between harvest date and QIN for any of the varieties. For Shiraz, harvest date had a strong positive relationship with crop load (r=0.71). Merlot's harvest date was also positively correlated with crop load (r=0.49).

2003 Data

Negative correlation between QIN and harvest date for Cabernet Sauvignon (r = -0.44) and Shiraz (r = -0.4), therefore it appears that for Cabernet Sauvignon and Shiraz the QIN score is higher in fruit harvested earlier. There was no clear trend for Merlot.

There was a positive correlation between crop load and harvest dates for Shiraz (r = 0.4).

2004 Data

No relationship between QIN and harvest date for any of the varieties. However there was a positive relationship between crop load and harvest date for Cabernet Sauvignon (r = 0.53).

2005 Data

No relationship between QIN and harvest date for Cabernet Sauvignon and Shiraz. There was a negative relationship between harvest date and QIN for Merlot (r = -0.534), and Merlot's harvest date and colour (r = -0.543).

Take home message: Early harvested fruit in some years produces better quality fruit. Heavy crop loads tend to delay maturity of Shiraz.

SUMMARY OF LITERATURE REVIEW AND INDUSTRY DATA

Most of the research that examines whether early ripening fruit produces better quality is on Shiraz, for which there does seem to be a relationship between harvest date and quality. However this is not a clear cut rule as there are many examples in the literature of later ripening Shiraz also producing good quality fruit. Late ripening Shiraz tends to be due to higher yields, and for these higher yielding vines to achieve quality the literature demonstrates that there needs to be a good balance between fruit and actively photosynthesizing leaves. This is achieved by producing a large, open canopy that allows sufficient sunlight to reach the inner leaves and maintain a high, effective leaf area well into the season.

Published information on how to achieve early ripening in wine grapes is also largely focused on the Shiraz variety. Shiraz will ripen early if it not excessively irrigated and more specifically if an irrigation stress is applied pre-veraison and a moderate irrigation is applied after veraison. Shiraz will also have a tendency to ripen early if it has a low crop load (kg of fruit/m^2 of canopy). There also seems to be a relationship with the age of the Shiraz vine; the older the vine, the more likely the fruit will ripen early. Shiraz may also ripen early if it is able to achieve maximum sugar transport into the berry before shrivel (beginning 90 days after flowering).

There is little work on harvest time and fruit/wine quality on varieties other than Shiraz. An exception is work by Bravdo (1995), who found for Cabernet Sauvignon that it is not a 'delayed harvest' that negatively impacts wine quality, rather that management techniques or inputs cause the 'delayed harvest'. He found excessive irrigation delayed harvest and had a negative impact on wine quality, whereas a high crop load, which also delayed harvest, did not negatively influence wine quality.

Numerous other studies have found that excessive irrigation is detrimental to fruit/wine quality. Over-watering vines is an undesirable practice for two reasons. Firstly, over-watered vines tend to produce leafy canopies that are dense, resulting in reduced sun light on lower leaves and therefore a decline in sugar production during berry maturation. Secondly, canopies that continue to grow during the fruit ripening stage are diverting energy into vegetative growth at the expense of sugar accumulation in the berries.

The relationship between yield levels and fruit maturation is not a direct relationship, while there are many studies that have shown an increase in ^{o}Brix in response to reduced yields, other research has reported no consistent response of yield reduction to sugar production. Lowering yield by cluster thinning is often cited as a method for preventing delayed ripening, however this research has often been undertaken on overcropped vines. For Shiraz, work has shown that vines with moderate yields are able to ripen the fruit in a timely fashion (Holzapfel 1999), given that there are enough actively photosynthesizing leaves to produce sugar.

A problem that often exists with research that examines the relationship between harvest date and fruit (or wine) quality is whether the harvest date is determined by optimal fruit maturity, seasonal weather conditions, or the grape intake logistics of the winery. Therefore any correlations between fruit quality and harvest date need to consider whether the fruit was harvested at its optimal ripeness or whether there were some other overriding factors that influenced the harvest date.

Another problem with the relationship between harvest date and fruit quality, is that it may exist in one season and not hold true for the next. Such inconsistency has been demonstrated in SRM's project, "Development of a wine grape quality index", where a negative correlation for QIN and harvest date was shown in 2003 for Shiraz and Cabernet Sauvignon and in 2005 for Merlot. Such inconsistency can be explained by the influence of weather conditions on fruit quality in each growing season. Changing weather conditions each year, changes the influence different viticulture management and inputs have on fruit quality. For example, delayed harvest in a year

with a number of heat waves may mean early harvested fruit is positively correlated with quality, however in a year with mild summer temperatures this relationship may not exist. Indeed this difficulty in drawing conclusions that apply to each growing season was highlighted by Krstic, who commented that it was 'difficult to draw consistent conclusions' about the relationship between rootstocks and quality when faced with completely different climatic conditions each growing season.

Should a grower be concerned with the harvest date of the fruit? It seems as if the harvest date does not have a convincing influence on fruit quality, and therefore growers should be cautious about assertions or statements linking these parameters. Growers in warm irrigated regions such the Murray Valley should probably be more focused on avoiding prolonged fruit maturation. Red winegrape varieties that are exposed to prolonged high vineyard temperatures may suffer a reduction in berry anthocyanin levels, which for our region has a strong relationship with quality and in some cases, grape payments. A drawn out harvest will also decrease fruit acid and increase pH, which is considered by winemakers to be detrimental to wine quality.

3. INTERVIEWS

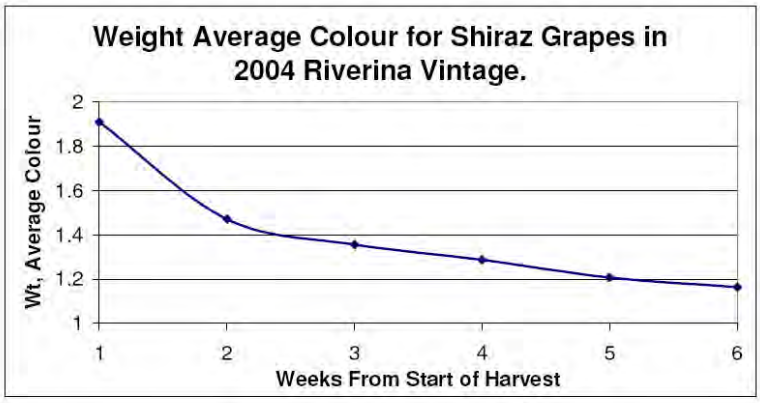
Thirteen interviews were conducted with winery personnel including winemakers and grower liaison officers, as well as wine industry organisations, private consultants and scientists from Victorian Department of Primary Industries and CSIRO.

All of the participants involved in the interviews, bar one, agreed there was a difference between early harvested fruit and early ripening fruit. This is a particularity important concept to grasp as early harvested fruit may not be ripe and vice versa.

Half of the respondents believed that early ripening fruit improved wine quality due to better acid/sugar balance, higher colour and improved flavour profile. One participant noted that early harvested fruit reduced the risk of damage from pest and disease injury and excessive heat loads.

The other half, who did not agree with the relationship between timing of fruit maturation and wine quality, opposed this proposition based on lack of evidence.

Only one winery provided evidence that supported their belief that earlier harvested Shiraz has better colour, see graph below, although this data was for a single year only.



For those who believed that early ripened fruit made better wine, the following management and environmental factors were cited as influencing the rate of ripening:

- Geographical location
- Crop thinning at certain times
- Site specific, soils, rootstocks and crop load
- Latitude – there is a difference in ripening times between Nangiloc and Yelta.
- Irrigation, fertilisation and pruning
- Combination of managerial practices and location

Scientific evidence cited by participants to support claims for early ripening and fruit/wine quality included: Krstic, M. & Hannah, R. (2003) Matching rootstocks and Scion Combinations in Sunraysia; Clingeleffer P. (2001) Crop Development, Crop Estimation, Crop Control to Secure Quality and Production of Major Wine and Grape Varieties: A National Approach; Ribereau-Gayon, P *et al* (2000) Handbook of Enology.

The question was asked whether the respondents (who supported the proposition that early ripened fruit made better wine) believed that this was consistent from year to year. The answers to this question were varied; no; yes; it's seasonally based; yes, providing management practices counterbalance the climatic fluctuations.

Participants were asked, 'What are the characteristics associated with early harvested fruit that help to make better quality wine?' The answers to this question included:

- Acid/sugar balance, no pH >4, low pH
- Better colour levels
- Physiological ripeness, better balanced chemical profile
- Tannin structure

In conclusion, everyone agreed that the hectic pace of vintage and batching issues had an impact on wine quality. There was some concern that the early ripened fruit may get picked at optimum maturity whereas the fruit picked mid season is picked based on scheduling rather than optimal maturity. Another issue raised was the actual winemaking techniques used in Sunraysia: "quality isn't made through rushed hot ferments".

Probably the most compelling reason why growers may want to harvest their fruit early is to decrease the risk of damage caused by unfavourable weather (i.e. heat waves, rain, hail) and reduce the possibility of injury from pest and diseases.

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APPENDIX 2

Early ripening fruit

Impact on quality

Susan Saris
Scholefield Robinson, Mildura

Scholefield Robinson Mildura (SRM) has been contracted by Murray Valley Winegrowers' Inc. (MVW) to determine whether early ripening fruit results in better quality fruit and wine. The project – known as Preventing Delayed Ripening - resulted from an application for funding to the Murray Valley Winegrape Industry Development Committee and approval by growers for MVW to manage the process.
The project took account of the opinions of local winemakers and scientists via an industry questionnaire, reviewed relevant scientific papers and drew on data gathered by SRM as part of quality benchmarking over the past six years.
The main findings of the project are as follows:

Literature review:

- Most of the research examining whether early ripening fruit produces better quality has been based on Shiraz, for which there does seem to be a relationship between harvest date and quality. However, this is not a clear-cut rule as there are many examples in the literature of later ripening Shiraz also producing good quality fruit.
- **Numerous research papers support the finding that excessive irrigation delays harvest and is detrimental to fruit/wine quality.**
- There is no direct relationship between yield levels and fruit maturation (harvest date). While there are many studies that have shown an increase in oBrix in response to reduced yields, other research has reported no consistent connection between sugar production and yield reduction. A better measurement of a vine's ability to ripen fruit adequately without delay is crop load - the ratio of actively photosynthesizing leaves to fruit weight.
- Any correlations between fruit quality and harvest date need to consider whether the fruit was harvested at its optimal ripeness or whether factors such as seasonal weather conditions or grape intake logistics influenced the harvest date.
- Growers in warm irrigated regions such as the Murray Valley and Riverland should probably be more focused on avoiding prolonged fruit maturation. Red varieties that are exposed to prolonged high vineyard temperatures may suffer a reduction in berry anthocyanin levels. A drawn out harvest will also decrease fruit acid and increase pH.

Industry data:

- SRM's project, "Development of a wine grape quality index" has for the last six years demonstrated an inconsistent relationship between harvest date and fruit quality. There was a negative correlation of QIN (Quality Index Number) and harvest date in 2003 for Shiraz and Cabernet Sauvignon and in 2005 for Merlot. Such inconsistencies can be explained by the influence of weather conditions on fruit quality in each growing season.

Interviews:

- Half of the respondents to the industry questionnaire believed that early ripening fruit improved wine quality due to better acid/sugar balance, higher colour and improved flavour profile.
- There was little objective evidence provided by respondents to support these assertions.

Early harvest is not a critical issue for red winegrape quality. However, a delayed harvest should be avoided as it can be detrimental to grape quality. Growers should focus on determining a crop load that optimises the flavour, aroma and colour potential of their fruit while providing a profitable yield.

