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The effects of light pruning, irrigation and improved soil management on wine quality of the *Vitis vinifera* cv. Riesling

by

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Der Einfluß von schwachem Rebschnitt, Bewässerung und verbesserter Bodenbearbeitung auf die Weinqualität der Rebsorte Riesling (*Vitis vinifera*)

Zusammenfassung: Der Einfluß einer Reihe ertragsverbessernder Weinbaumaßnahmen auf die Weinqualität wurde untersucht. Hierbei handelte es sich um verbesserte Bodenbearbeitung, schwachen Rückschnitt/höhere Erziehung, Bewässerung sowie eine Kontrolle. Im ersten Versuchsjahr hatte ein Ertragszuwachs von 1,6 t/ha bei Bewässerung keinen signifikanten Einfluß auf die Weinqualität. Es wird ein Verfahren beschrieben, mit dem — als Teil der sensorischen Analyse — Verläßlichkeit, Unterscheidungsvermögen, Variabilität und Stetigkeit der Prüfer beurteilt werden können. Vier Prüfer waren ständig in der Lage, Unterschiede zwischen den Prüfgliedern zu erkennen.

Key words: pruning, irrigation, soil improvement, must, wine, yield, wine quality, sensory rating, statistics.

Introduction

Traditional viticultural practices in the Barossa Valley, South Australia, have led to a decline in the viability of grape growing in the region (10). The major constraint is that of low yields resulting from lack of water, and severe pruning in conjunction with a low trellis. On average the evapotranspiration (October—March) in the Barossa Valley exceeds growing season rainfall by about 400 mm which, after accounting for a variable 50—200 mm soil water storage of winter rainfall leaves a substantial water deficit.

This study was established to measure the effects of several yield stimulating viticultural treatments on final wine quality. Typically in such studies the sensory evaluation aspects are given cursory consideration. However, it is necessary to establish sensory differences in order to validate the relevance of any viticultural differences. A major source of variability in sensory evaluation is judge performance, and the approach of undertaking a detailed analysis of judge performance was adopted. Unreliable judges were eliminated to reduce judge variability prior to the analysis for wine differences. Several researchers recommend this technique. (2, 5, 6, 13).

Materials and methods

A split-plot-type factorial experiment with three factors — irrigation, lighter pruning/higher trellis, and improved soil management — was established at Lights Pass in the Barossa Valley in 1981 on 18-year-old own-rooted Riesling vines (Survey).

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Survey

Viticultural treatment · Source: SODERLUND *et al.* (12)

Weinbauliche Maßnahmen (nach SODERLUND *et al.* (12))

Traditional management programme	Improved management
Irrigation	
No irrigation for 3 years	Trickle irrigation at 0.2 × Class A pan evaporation
Pruning/trellising	
Pruned to 36 nodes (3 × 10-node canes + 3 × 2-node spurs)	Pruned to 72 nodes (6 × 10-node canes + 6 × 2-node spurs)
T trellis with fruit wires 0.3 m apart at 0.8 m above ground, single foliage wire at 1.1 m	Taller, vertical trellis, single fruit wire at 1.1 m, single foliage wire at 1.55 m
Soil management	
Cultivation 4—6 times/season to remove weeds	Ripping, addition of fertilizers and ameliorants, formation of banks under vine, weed control by herbicide

The irrigation treatment had water supplied at 0.2 of Class A pan evaporation from mid-December until the end of February, giving a total water application of 160 mm. The lighter pruning consisted of retaining 6 × 10-node canes trained up onto a fruiting wire 1.1 m above ground. For improved soil management treatment the soil, a red-brown sandy loam (30—45 cm depth) over light clay, was ripped to approximately 60 cm. Gypsum and *Pinus radiata* sawdust was incorporated at rates of 36 and 11 t/ha respectively. The control vines were pruned to 3 × 2-node renewal spurs plus 3 × 10-node canes trained on a narrow T (30 cm) 0.8 m above ground level.

From a total of eight treatments, five which indicated viticultural differences, were selected for wine quality assessment. These were: Control (C); Improved Soil Management (ISM); Lighter Pruning/Higher Trellis (LPHT); Irrigation (I); Improved Soil Management + Lighter Pruning/Higher Trellis + Irrigation (ISM-LPHT-I). Three of the six field replicates were processed into wine replicates. The fruit was harvested into 18 kg capacity picking crates and stored at 2 °C for 24 h after the addition of potassium metabisulphite (180 ppm SO_2) and sodium erythorbate (100 ppm). The fruit was processed using a Zambelli 5 t/h crusher and drained through a waterbag press (8) at 20 psi. The juice was enzyme settled (30 mg/l) at 2 °C and after 5 d the clean juice racked off enzyme lees into 22 l fermentation vessels.

The juice was analysed for °Brix, pH, total acidity and the fermenters inoculated with 5 % by volume actively fermenting starter culture (10^8 cells/ml) of dried wine yeast *Saccharomyces cerevisiae*. At the end of fermentation the wines were checked for reducing sugar and all contained less than 0.2 %. The wines were then racked off gross lees and adjusted to 30 ppm free SO_2 before bentonite fining at 1.0 g/l and a tartaric acid addition of 1.0 g/l. Tartaric acid additions were made to the wine prior to cold stabilisation in order to adjust the pH values to approximately the same levels prior to sensory evaluation. The wines were cold stabilised at 2 °C for 3 weeks before bottling. The finished wines were analysed for percent alcohol using an ebulliometer, free and total SO_2 using the aspiration method, optical density at 420 nm, pH and titratable acidity expressed as tartaric acid. The optical density values (E_{420}) give an indication of colour and the degree of oxidative browning. All wines were assessed prior to the tasting and were considered of commercial standard with no obvious defects.

3 months after bottling, the wines were presented to six experienced judges, two of whom — 4 and 5 — are Australian wine show judges. The wines were scored using the Australian wine show 20-point score card (7).

The wines were presented in six groups of five, such that each sitting contained a replicate of each of the treatments. All wines were seen twice during the tasting to provide estimates of judge performance and reliability. Two-way analysis of variance was carried out on both juice and wine composition data. The analyses of variance performed on the wine scores were derived from the experimental structure as described by BRIEN (3), the experimental structure for an analysis of scores from two or more judges being:

Tier	Structure formulae
1	Judges · (Occasions/Sessions/Glasses)
2	(Blocks/Plots) · Judges · Occasions
3	Treatments · Judges · Occasions

The expected mean squares, which are used to determine the mean squares involved in F-tests, are shown in the Appendix.

The structure, and hence analysis, for a single judge is obtained by deleting the Judges factor. The analyses were performed using GENSTAT (1).

Results and discussion

From Table 1 it can be seen that a significant increase in yield was achieved by all treatments apart from the improved soil management. SODERLUND *et al.* (12) found that the improved soil management resulted in no yield change in the first year and a slight decrease in the following season. This was attributed to the reduction in the vine's water uptake capacity due to extensive loss of roots in establishing the improved soil management banks. The LPHT treatment increased shoots/vine giving a slight yield increase over the control due to the fact that there were fewer clusters/shoot, berries/cluster and the berries were smaller, in the control. Irrigation gave increased yield due mainly to increased berries/cluster and increased berry weight.

From berry sampling data for the total eight treatment combinations and six replicates, SODERLUND *et al.* (12) found no significant difference in °Brix but the pH and titratable acidity of the LPHT treatment were significantly lower and higher respectively ($P = 0.05$). However, the crushed must samples used for the three winemaking replicates showed that the treatments had no significant effect on the juice composition (Table 1).

After bottling, the control wines showed the highest optical density at 420 nm (Table 2). The level was significantly higher ($P = 0.05$) than LPHT; I and the combined treatments, possibly indicating higher levels of oxidation. Treatment ISM-LPHT-I had the lowest optical density.

Table 1

Fruit weight and settled juice composition

Traubenerträge und Zusammensetzung der geklärten Moste

Treatment	Yield (t/ha)	°Brix	pH	Total acid. (g/l)
Control (C)	4.7 a	21.9	3.3	4.7
Improved Soil Management (ISM)	5.1 ab	22.5	3.3	4.6
Lighter Pruning/Higher Trellis (LPHT)	6.2 b	21.3	3.2	5.1
Irrigation (I)	6.3 b	22.1	3.3	5.0
ISM-LPHT-I	6.4 b	22.0	3.2	5.1
LSD 5 %	1.3	NS	NS	NS

Following BRIEN (2) and BRIEN *et al.* (5), the performance of the judges, in particular their reliability, discrimination, variability, stability and agreement, was evaluated. A measure of judge reliability is given by the correlation of the scores given on the same wine by each judge during the course of the tasting.

Table 3 shows that only judges 4 and 5 were highly reliable ($P = 0.001$) in their judgements. Judges 2 and 6 had significant correlation at the 5 % level and judges 1 and 3 showed no significant correlation for scoring on the same wine. The R^2 shows a moderate relationship between the first score and the second score for judges 4 and 5, weak for judges 2 and 6 and very weak for judges 1 and 3. Reliability, however, is only one attribute in the assessment of judge performance since there is a need for a judge to be able to discriminate between wines when a real difference exists. Judge discrimination is indicated by the F-value for wines from the A.O.V. tables. Table 3 shows that judges 4 and 5 were able to discriminate better than other judges and find wine differences and that judges 2, 3 and 6 found smaller wine differences. Judge 3 changed his level of scoring from one occasion to the next.

Table 4 presents multijudge correlation matrices for Session 1 and Session 2, which measure agreement between judges. It can be seen that the judges in general show very poor agreement and in fact the scores for judge 2 for Session 2 tend to indicate a negative correlation with all other judges. Judges 4 and 5 show reasonable agreement for Occasion 1 ($r = 0.54$) and Session 2 ($r = 0.68$). Judge 1 and 5 show good

Table 2

Wine composition mean values of three replicates

Mittelwerte der Weinzusammensetzung aus drei Wiederholungen

Treatment	E_{420}	Alcohol (% v/v)	pH	Total acid. (g/l)	Free SO_2 (mg/l)
C	0.010 c	12.7	2.9	6.4	20.7
ISM	0.008 bc	13.7	2.9	6.1	18.7
LPHT	0.005 b	12.5	2.9	6.5	20.0
I	0.004 ab	13.05	2.9	6.4	26.3
ISM-LPHT-I	0.002 a	12.65	2.9	6.2	26.7
LSD 5 %	0.004	NS	NS	NS	NS

Table 3

Judge reliability and performance

Verläßlichkeit und Leistungen der Prüfer

Judge	Reliability (correlation coefficient)	R^2 (coefficient of determination)	Judge discrimination (F-value wines)	Variability (LSD individual wine scores)	Stability
1	0.33 NS	11	2.54 NS	7.37	1.71 NS
2	0.53 *	28	4.61 *	2.23	2.67 NS
3	0.46 NS	21	4.06 *	3.66	6.65 *
4	0.84 ***	71	9.57 **	2.34	0.83 NS
5	0.86 ***	74	14.50 ***	2.86	0.81 NS
6	0.52 *	27	4.07 *	3.31	2.32 NS

correlation for Session 1 ($r = 0.74$) but poor relationship for Session 2 ($r = 0.16$). This is the result of judge 1's poor reliability (Table 3).

The above evaluation of judge performance indicates that the assumption of homoscedasticity would not be met if all judges were included in a combined analysis as they have different reliabilities, variability in scoring, discrimination and agreement. (Similar results have been reported in BRIEN 1982 and BRIEN *et al.* 1985.)

It would appear that any conclusions about differences in wine quality should be based primarily on judges 4 and 5 and to a lesser extent judges 3 and 6. Combined analyses for each of these two pairs of judges are presented in Table 5. For judges 4 and 5, there was significant variation in the judges' evaluation of lot and treatment differences which varied from one occasion to the other.

In spite of this, the significant residual under Blocks · Lots indicates that the judges were able to establish consistent differences between the plots (see Table 6). However, there are no significant overall treatment effects. Judges 3 and 6 also found differences between the lots but without the variation between judges and occasions exhibited by judges 4 and 6. Again, there were no significant overall treatment effects.

Table 4

Correlation matrix between judge wine scores on two different occasions

Matrix der Korrelation zwischen den Boniturnoten der Prüfer bei zwei verschiedenen Weinproben

	Occasion 1						Occasion 2					
Judge	1	2	3	4	5	6	1	2	3	4	5	6
1	1.00						1.00					
2	0.35	1.00					−0.13	1.00				
3	0.30	−0.31	1.00				0.34	−0.28	1.00			
4	0.58	0.34	0.27	1.00			0.49	−0.24	0.54	1.00		
5	0.74	0.07	0.53	0.54	1.00		0.16	−0.02	0.66	0.68	1.00	
6	0.46	−0.04	0.69	0.19	0.70	1.00	0.20	−0.23	0.60	0.20	0.11	1.00

Table 5

Combined analysis of scores assigned by judges 4 and 5

Kombinierte Analyse der durch die Prüfer 4 und 5 vergebenen Boniturnoten

Source	df		Judges 4, 5		Judges 3, 6	
			MSQ	F[1])	MSQ	F[1])
Judges	1		37.60	7.92 NS	5.62	13.48 NS
Occasions	1		0.50	1.40 NS	3.27	4.61 NS
Judges · Occasions	1		0.34	0.15 NS	0.42	7.69 NS
Occasions · Sessions	4					
Blocks		2	12.18	2.57 NS	6.25	20.56*
Blocks · Occasions		2	0.40	0.31 NS	0.30	5.61 NS
Judges · Occasions · Sessions	4					
Blocks · Judges		2	3.70	0.93 NS	0.09	1.70 NS
Blocks · Judges · Occasions		2	0.76	4.26 NS	0.05	0.06 NS
Judges · Occasions · Sessions · Glasses	48					
Blocks · Plots		12				
Treatments		4	11.23	0.89 NS	3.88	1.05 NS
Residual		8	13.43	3.02 NS	3.69	4.11*
Blocks · Plots · Judges	12					
Treatments · Judges		4	1.65	0.48 NS	0.39	0.67 NS
Residual		8	3.40	18.97**	0.58	0.64 NS
Blocks · Plots · Occasions	12					
Treatments · Occasions		4	0.36	0.25*	0.69	0.77 NS
Residual		8	1.10	6.15*	1.39	1.55 NS
Blocks · Plots · Judges · Occasions	12					
Treatments · Occasions · Judges		4	1.07	5.95*	0.32	0.36 NS
Residual		8	0.18		0.90	
Total	59					

[1]) Many of the degrees of freedom for F-tests are not integer values because the F-values are ratios of sums of mean squares expressions for the degrees of freedom of which are given by SATTERTHWAITE (9).

This point highlights the difficulties in applying viticultural treatments and obtaining a significant response in terms of wine quality, since both the differences evident at the viticultural stage of the trial may not result in detectable differences in the fermentation and sensory evaluation stages. However, since the final product from wine grapes is the wine itself, it is imperative that the final assessment be in terms of wine quality.

The importance of having fermentation replicates can not be too strongly emphasised. In this trial, field replicates were made into wine replicates so the contribution of field and fermentation differences to the lot differences found by the judges could not be separated. However, we are still able to conclude that while some of the judges could

Table 6

Wine scores Block · Plot means for judges 4 and 5

Mittelwerte der Weinboniturnoten für Block · Parzelle bei den Prüfern 4 und 5

Treatment	Block			Mean
	1	2	3	
C	13.37	16.87	14.50	14.92
ISM	14.00	15.50	14.13	14.54
LPHT	16.75	13.87	16.63	15.75
I	12.87	16.87	15.75	15.17
ISM-LPHT-I	12.25	11.38	15.87	13.17

detect lot differences, if we had not replicated this important source of co-variation we may have been led to conclude, erroneously, that there were treatment differences — the treatment differences being, in reality, lot differences.

Conclusion

The yield increase (134 %) caused by the use of irrigation had no discernible effect on final wine quality in the first year of the trial. Similarly, there was no effect of any of the applied viticultural treatments on wine quality. Although there was a considerable percent increase in yield with all treatments except improved soil management (ISM), the highest yield of 6.4 t/ha would be regarded commercially as low. It is obvious that large differences in field experiments are necessary in order to generate valid wine quality differences detectable by sensory evaluation. SMART (11) found that large must and wine differences yielded significant differences. Further differences may arise in later years of the trial.

The inclusion of field/fermentation replicates to ensure the validity of observed treatment differences and the evaluation of panel performance to reduce extraneous responses are seen as important in trials for evaluating the effects of viticultural practices on wine quality.

Summary

A number of yield improving viticultural practices were assessed in terms of their effect on wine quality. These were improved soil management, lighter pruning/higher trellis, irrigation and a control. In the first year a yield increase of 1.6 t/ha for the irrigation treatment had no significant effect on wine quality. A procedure is presented to assess judges for reliability, discrimination, variability and stability as part of analysis of the sensory results. Four judges were able to consistently identify lot differences.

Appendix

Expected mean squares for combined analysis of two judges' scores derived as described by Brien (4)

Erwartete Mittlere Abweichungsquadrate zur kombinierten Analyse der Boniturnoten zweier Prüfer (nach Angaben von Brien (4))

Source	df	Expected mean squares[1]															
		φ_{JOSG}	φ_{JOS}	φ_{OS}	φ_{JO}	φ_{O}	φ_{BLJO}	φ_{BLO}	φ_{BLJ}	φ_{BL}	φ_{BJO}	φ_{BJ}	φ_{BO}	φ_{B}	φ_{TOJ}	φ_{TO}	(μ_{JT})[2]
J	1	1	5		15		1		2		5	10			3		$f(\mu_{JT})$
O	1	1	5	10	15	3	1	2			5		10		3	6	
J · O	1	1	5		15		1				5				3		
O · S	4																
B	2	1	5	10			1	2	2	4	5	10	10	2			
B · O	2	1	5	10			1	2			5		10				
J · O · S	4								2		5	10					
B · J	2	1	5				1				5						
B · J · O	2	1	5				1										
J · O · S · G	48																
B · L	12																
T	4	1					1	2	2	4					3	6	$g(\mu_{JT})$
Residual	8	1					1	2	2	4							
B · L · J	12																
T · J	4	1					1		2								$h(\mu_{JT})$
Residual	8	1					1		2								
B · L · O	12																
T · O	4	1					1	2							3	6	
Residual	8	1					1	2									
B · L · J · O	12																
T · O · J	4	1					1										
Residual	8	1					1								3		

J = Judge, O = Occasion, S = Session, G = Glass, B = Block, P = Plot, T = Treatment.

[1]) φs are canonical covariance components, a particular φ denoting the extra covariation (and hence correlation) between individuals having the same levels of the subscripted factors.

[2]) μ_{JT} denotes the expectation of the observations which, in general, may be different for each Jugde · Treatment combination.

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