Rootstock effects on wine grapes

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Chardonnay and Cabernet Sauvignon varieties were grafted onto phylloxera-resistant rootstocks in a vineyard not yet infested with the insect in the south central coastal region. Rootstocks influenced growth and yield, as well as composition and quality of juice and wine, but a major consideration would be phylloxera resistance.

Rootstock 1202C (left) shows excellent compatibility with Chardonnay scions. It was a vigorous, high-yielding stock. Union of rootstock 110R with Chardonnay (right) is conspicuous because of scion overgrowth. Wine sensory scores showed relatively little difference among rootstocks.

For more than 100 years, California grape growers have been using rootstocks for resistance to grape phylloxera, an aphidlike insect that forms galls on vine roots. Numerous rootstock evaluations over the last 35 years by University of California viticulturists at Davis have resulted in the identification of AxR#1 (Aramon x *rupestris* Ganzin 1) as a useful rootstock for the northern coastal valley vineyards. None of these studies, however, was conducted in the south central coastal region—San Luis Obispo and Santa Barbara counties.

About 20,000 acres of new vineyards for wine grape production have been planted in the last 20 years in San Luis Obispo and Santa Barbara counties. Nearly all of the plantings have been own-rooted, that is, not on phylloxera-resistant rootstocks. Although phylloxera was not present at the time of the plantings, it is a potentially serious problem as vineyards age and as the probability increases for a chance introduction of the pest.

We therefore established six rootstock evaluation experiments, three in San Luis Obispo County and three in Santa Barbara. This report presents results from two of the trials, one with Chardonnay scions and the other with Cabernet Sauvignon, both in the Vina de Santa Ynez Vineyard, just west of Santa Ynez in Santa Barbara County.

Methods

Rootstocks were grafted and grown by the UC Department of Viticulture and Enology at Davis. The eight rootstocks and own-rooted vines were established in 1976, with replanting in 1978, at a density of 605 vines per acre. Vines were trained to a two-wire vertical trellis and pruned to four canes per vine. The vineyard, on a Ballard clay loam soil, was cultivated between rows, and a herbicide strip down the vine row was maintained by preemergence herbicides. Irrigation was by permanent-set overhead sprinklers. Yield and pruning weights from each vine, and juice and wine composition and wine sensory analysis for quality were obtained from four replications of five experimental vine units each for 4 years for Cabernet Sauvignon and 3 years for Chardonnay.

After harvesting, grapes were transported to Davis and crushed the next day. Chardonnay was pressed immediately in a basket press (equivalent to winery free-run juice). Cabernet Sauvignon was fermented on the skins to about 5°Brix then lightly pressed. Sulfur dioxide (35 to 50 milligrams per liter [mg/L]) was added to each lot before addition of yeast, *Saccharomyces cerevisiae* strain Montrachet (UCD Enology No. 522). The Chardonnay was settled overnight, racked, and fermented at 60°F. The Cabernet Sauvignon was fermented at 70°F with caps punched down twice daily. The °Brix reading was taken as necessary to follow the fermentation. When the wines were dry, they were taken to the cellar for clarification and cold stabilization. All samples were held in glass. Small amounts of sulfur dioxide were added at the time of filtration. Storage was at 52°F.

For the first 3 years (1984-86), samples of the field replicates were fermented separately, and analyses of the juice and wines were averaged. In 1987, field samples were

crushed separately and juice samples analyzed, then combined and fermented in treatment lots.

The juice samples were taken after the lots were pressed and analyzed for °Brix, total acidity, and pH. The wine samples were analyzed after cold stabilization for total acidity, pH, ethanol, potassium, total phenols, and color.

The sensory analysis was done using the 20-point scoring system of M. A. Amerine and E. B. Roessler, of UC Davis, which allows wines to be rated for appearance, aroma, flavor, balance, and other quality parameters. The tastings were presented in blocks of nine per day. Each taster received nine different rootstock treatments at a sitting, and each made eight replications to ensure that significant variations would be detected. We performed statistical analysis of each year's sensory scores. Seven to ten tasters participated each year.

Results

Cabernet Sauvignon. Growth was determined by pruning weight measurements from each vine over a 4-year period (table 1). Scion growth was significantly greater on 1202C than on all the other rootstocks each year. It was followed by 5A, which was significantly greater than the others for the 4-year average only. The six remaining rootstocks showed very small differences, although Harmony was consistently low each year.

Yield comparisons resulted in a different grouping, with AxR#1, SO4, 1202C, own-rootstocks, 5A, and 3309C all in the top group over the 4-year period (table 1). Harmony was the lowest producing stock.

The juices varied considerably from year to year, but treatment differences (table 2) were quite small. AxR#1 had the lowest soluble solids at an average 22.3°Brix, and Harmony the highest at 23.6°Brix. In total acidity, 5A was highest and Harmony lowest, with a range of 0.71 to 0.80 gram tartaric acid per 100 milliliters of juice (H_2Ta/100 ml). The pH reflected the °Brix and acidity measurements; Harmony had the highest pH and AxR#1 the lowest. These differences may be partially due to differences in cropping level, vigor, or both.

The total acidity of the wine showed a much narrower range, 0.70 to 0.73 (table 2). Average wine pH values ranged from 3.61 for AxR#1 to 3.80 for St. George. Higher wine pH may have been partially due to the greater uptake of potassium, since AxR#1 had an average of 1316 mg/L potassium and St. George had 1663 mg/L.

Ethanol levels reflect the °Brix of the juice and any raisined fruit that might not have been broken open and the sugar dissolved in the must sample. AxR#1 had the lowest ethanol and SO4 the highest, followed by Harmony.

TABLE 1. Rootstock effect on cane pruning weight and fruit yield, Cabernet Sauvignon, 1984-87

Rootstock	1984	1985	1986	1987	Average*
			Pruning weight (lb/vine)		
1202C	6.1	7.2	6.7	5.8	6.5 a
5A	4.2	4.7	4.9	4.3	4.5 b
St. George	3.4	5.1	4.8	4.1	4.4 bc
SO4	3.9	4.4	4.2	4.3	4.2 bc
Own	3.0	5.0	4.1	4.2	4.1 bc
3309C	4.0	4.1	4.5	3.3	4.0 bc
AxR#1	3.9	4.0	3.7	3.9	3.9 bc
110R	2.9	3.3	3.4	3.0	3.2 bc
Harmony	3.1	2.9	3.2	2.9	3.0 c
			Fruit yield (lb/vine)		
AxR#1	16.6	19.0	13.7	13.8	15.8 a
SO4	13.6	15.6	15.0	13.4	14.4 ab
1202C	12.3	19.1	14.0	10.8	14.1 ab
Own	11.8	18.4	12.4	11.5	13.5 ab
5A	13.9	14.0	14.3	11.8	13.5 ab
3309C	13.0	11.3	15.3	10.7	12.6 ab
110R	14.0	17.1	12.0	7.0	12.5 b
St. George	11.6	14.9	11.8	11.4	12.4 b
Harmony	11.7	9.4	9.6	5.5	9.1 c

* Averages followed by the same letter are not significantly different by Duncan's Multiple Range Test, p=0.05.

TABLE 2. Cabernet Sauvignon juice and wine analysis, data averaged, 1984-87

	Juice analysis			Wine analysis						
Rootstock	°Brix	Total acidity	pH	Total acidity	pH	Ethanol	Potassium	Total phenol	Color O.D.* 420 nm	Color O.D.* 520 nm
		g H_2Ta/100 ml		*g H_2Ta/100 ml*		*%v/v*	*mg/L*	*mg/L*		
Harmony	23.6	0.71	3.66	0.71	3.79	13.3	1596	1754	3.24	5.19
St. George	22.9	0.74	3.62	0.71	3.80	12.9	1663	1591	2.87	4.57
AxR#1	22.3	0.73	3.52	0.72	3.61	12.7	1316	1486	2.66	4.93
5A	23.3	0.80	3.56	0.73	3.70	13.2	1543	1541	2.90	4.85
Own	23.1	0.73	3.61	0.70	3.73	13.2	1584	1560	2.66	4.41
SO4	23.4	0.75	3.61	0.71	3.78	13.5	1599	1604	2.76	4.62
1202C	23.2	0.76	3.58	0.72	3.73	13.2	1608	1511	2.71	4.49
110R	22.9	0.76	3.57	0.73	3.67	12.9	1440	1594	2.88	5.01
3309C	23.2	0.78	3.58	0.73	3.71	13.1	1544	1568	2.71	4.54

NOTE: All juice analyses performed as described by M. A. Amerine and C. S. Ough, *Methods of Analysis of Musts and Wines*, J. Wiley and Sons, New York, 1980.
* O.D. = optical density.

TABLE 3. Cabernet Sauvignon sensory evaluations, average sensory scores, 1984-87

	Score*			
Rootstock	1984	1985	1986	1987
Harmony	13.63 a	13.56 ab	14.07 ab	13.75 ab
St. George	13.58 a	13.50 b	13.71 cde	13.62 ab
AxR#1	13.55 ab	13.83 a	14.00 abc	13.57 ab
5A	13.53 ab	13.77 ab	13.59 def	13.20 c
Own	13.40 ab	13.58 ab	13.80 bcd	13.68 ab
SO4	13.40 ab	13.60 ab	12.91 g	13.48 bc
1202C	13.30 abc	13.75 ab	13.46 ef	13.71 ab
110R	13.18 bc	13.79 ab	14.21 a	13.84 a
3309C	12.93 c	13.69 ab	13.38 f	13.70 ab
LSD .05	0.38	0.29	0.29	0.32

NOTE: Sensory analysis was by the 20-point scoring system of M. A. Amerine and E. B. Roessler, *Wines, Their Sensory Evaluation*, 2nd edition, W. H. Freeman Company, San Francisco, 1983. Larger numbers indicate higher quality.
*Averages followed by the same letter are not significantly different. Comparison made within individual years.

The total phenols were consistent with results of the other analyses: AxR#1 had the lowest total phenol values and Harmony the highest. Harmony had the highest wine color when measured at 420 or 520 nanometers (nm) (420 represents brownness and 520 redness of the tint). There was relatively little difference in the 420 nm absorbance of the other treatments.

The ratio of 520 nm/420 nm is another way to look at wine color. The larger the ratio, the more red the wine is and the less brown, a favorable character. AxR#1 had a ratio of 1.85; the rest fell between 1.59 and 1.74 with an average of 1.68.

The sensory evaluations indicated relatively small differences among treatments or years (table 3). Harmony, AxR#1, and

TABLE 4. Rootstock effect on cane pruning weight and fruit yield, Chardonnay, 1985-87

Rootstock	1985	1986	1987	Average*
	Pruning weight (lb/vine)			
1202C	1.9	3.4	2.8	2.7 a
5A	1.4	2.3	2.7	2.1 b
Own	1.0	2.3	2.0	1.8 bc
AxR#1	1.1	1.8	1.9	1.6 c
3309C	1.1	2.1	1.4	1.5 c
SO4	1.0	1.6	1.6	1.4 c
Harmony	0.8	1.9	1.3	1.3 c
110R	0.7	1.5	1.7	1.3 c
St. George	0.8	1.5	1.4	1.3 c
	Yield (lb/vine)			
AxR#1	27.9	16.1	21.0	21.7 a
5A	29.7	16.5	18.7	21.6 a
1202C	32.2	17.9	11.6	20.6 ab
3309C	27.6	15.5	14.0	19.0 abc
Own	23.7	13.3	16.6	17.9 abc
St. George	22.9	11.8	13.2	16.0 bc
SO4	22.2	10.5	13.8	15.5 c
110R	23.0	13.4	8.8	15.1 c
Harmony	12.9	8.3	7.4	9.5 d

*See table 1 footnote (*).

TABLE 5. Chardonnay juice and wine analysis, data averaged, 1984-87

	Juice analysis			Wine analysis					
Rootstock	°Brix	Total acidity	pH	Total acidity	pH	Ethanol	Potassium	Total phenol	Color O.D. 420 nm
		g H_2Ta/100 ml		g H_2Ta/100 ml		%v/v	mg/L	mg/L	
Harmony	23.7	0.99	3.34	0.82	3.18	14.1	385	262	0.090
St. George	23.4	0.92	3.34	0.81	3.20	14.0	381	253	0.096
AxR#1	22.5	0.95	3.30	0.84	3.15	13.6	421	246	0.085
5A	22.5	0.97	3.30	0.84	3.16	13.6	424	252	0.090
Own	22.0	0.95	3.36	0.81	3.23	13.0	400	254	0.100
SO4	23.3	0.93	3.34	0.80	3.17	13.8	407	278	0.111
1202C	23.4	0.99	3.30	0.82	3.17	14.0	398	273	0.091
110R	22.7	0.90	3.28	0.83	3.10	13.9	356	251	0.101
3309C	23.3	0.97	3.29	0.85	3.14	13.7	367	258	0.083

NOTE: See table 2 note.

TABLE 6. Chardonnay sensory evaluations, average sensory scores, 1985-87

	Score*		
Rootstock	1985	1986	1987
110R	12.98 a	13.29 bc	13.25 ab
3309C	12.92 a	13.47 abc	13.20 ab
AxR#1	12.88 ab	13.52 abc	13.23 ab
5A	12.83 ab	13.52 abc	13.16 ab
Harmony	12.75 abc	13.54 ab	13.29 a
Own	12.71 abc	13.27 bc	13.04 b
1202C	12.60 bc	13.52 abc	13.11 ab
St. George	12.52 c	13.44 abc	13.28 ab
SO4	12.52 c	13.58 a	13.18 ab
LSD .05	0.30	0.25	0.30

NOTE: See table 3 note.
*See table 3 (*) footnote.

own-rootstocks were in the top group in each of the 4 years; 3309C, St. George, 5A, and SO4 were in the bottom group in 2 of the 4 years; and 110R and 1202C were in the bottom group in 1 year. The 4-year average scores of 110R, Harmony, and AxR#1 were not significantly different, however, with values of 13.76, 13.75, and 13.74, respectively.

Chardonnay. Over a 3-year period, 1202C produced the greatest number of pounds of cane prunings per vine, followed closely by 5A and own-rootstocks (table 4). The remaining stocks were not significantly different.

AxR#1 and 5A produced the greatest yields, and 1202C, 3309C, and own-rootstocks were intermediate (table 4). Harmony was significantly the lowest yielding rootstock.

Juice analysis showed own-rootstocks to be lowest in °Brix and Harmony the highest (table 5). Total acidity ranged from 0.90 to 0.99, with 110R lowest and Harmony and 1202 highest. The pH values were in a narrow range.

Wine analyses showed less range in total acidity (0.80 to 0.85), and pH values were in a close range between 110R and St. George. Own-rootstocks had the lowest ethanol levels, Harmony the highest, and 1202 intermediate. Potassium values ranged from 356 mg/L for 110R to 424 for 5A, with a general scatter in between. Total phenol showed a narrow distribution of 251 to 278 mg/L, a range of 27 mg/L, close to the method error.

Color at 420 nm ranged from 0.083 to 0.111. Differences of this nature can occur from handling variations in small lots and are probably not important.

The wines in general were too high in acidity and commercially would need deacidification for best results. Further picking delay would lead to wines with too much ethanol and would require undesirable cellar treatments.

Sensory examination of the wines showed relatively little difference (table 6). In the 3 years tested, Harmony, AxR#1, 3309, and 5A were in the top group and were not statistically different in scores each year.

Conclusions

In the Cabernet Sauvignon trials, vine vigor as measured by pruning weight was significantly greatest with 1202C rootstocks. There were very small differences among most of the other stocks, although Harmony showed poor performance.

AxR#1 was the top performer in yield, followed by a group of five stocks that did not differ significantly over 4 years. Harmony was significantly the lowest producer.

Based on the results of tasting and wine analysis, AxR#1 is recommended as the rootstock for Cabernet Sauvignon, primarily because the color is excellent, pH is lowest in an area where high pH can be a problem, and phenol content is lower indicating possibly easier maturation of the wine. Because there were relatively small differences in sensory scores, the major reasons for the recommendation are the crop levels obtained and vine growth conditions. Further consideration of recent problems with AxR#1's lack of resistance to phylloxera may indicate that a more resistant stock would be a better choice.

The most vigorous stock for the Chardonnay vines was 1202, with 5A second. There were small differences among the remaining rootstocks. The highest yielding stocks included AxR#1, 5A, 1202C, and 3309C. While Harmony resulted in the highest sensory scores, better yields by AxR#1, 5A, and 3309C indicate that one of these would be the stock of choice. Relative resistance to phylloxera would be the criterion to judge by, if this is the only consideration.

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