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Yield Components and Fruit Composition of Six 'Cabernet Sauvignon' Grapevine Selections in the Central San Joaquin Valley, California

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Abstract

Six 'Cabernet Sauvignon' grapevine selections from the Foundation Plant Services (FPS), UC Davis, were evaluated near Fresno, California. Selections FPS 2, 8, 10, 21, 22, and 24, were planted in April 1997 as own-rooted cuttings, and fruit yield and composition were assessed annually from 2000 through 2003. Harvested on the same dates in a given year, selections 8, 21, and 22 had higher yields than the others because they had either: heavier berries, larger clusters, more clusters, or several of these variables. Selections had similar numbers of berries per cluster. Fruit of selections 22 and 24 generally matured first and the fruit of selection 2 matured last. Each selection had similar skin anthocyanin concentrations in the one year that pigments were measured.

Introduction

In California, 'Cabernet Sauvignon' is the most widely grown grapevine (*Vitis vinifera* L.) cultivar whose fruit are used for red wine. In 2003 there were more than 30,400 ha of 'Cabernet Sauvignon' vines statewide, with about 11% of those in the central and southern San Joaquin Valley (2). These regions have a very warm Region V climate, according to Winkler's classification system (9).

'Cabernet Sauvignon' grown in a warm climate may lack flavors that are characteristic of the cultivar, thus reducing its value. For example, the average 2003 statewide price for 'Cabernet Sauvignon' was $1,014 per ton, but Fresno County farmers received only $249 per ton (3). As a result, farmers in the San Joaquin Valley must maximize yield of acceptable-quality fruit (5), though some area farmers also wish to improve the composition of their fruit, hoping that wineries might offer them higher prices for it.

A fundamental step towards improving fruit yield and composition is the selection of germplasm that is best-suited for the region in which it will be grown. Foundation Plant Services (FPS) at the University of California, Davis, offers more than 30 'Cabernet Sauvignon' selections, and others have shown that some of these selections differ with respect to yield, growth, and fruit composition (1, 4, 8, 11). Selection 8 is the most widely planted in California, but its performance has only been evaluated against six others in two studies (1, 11), both of which were conducted in the Northern San Joaquin Valley, where the climate may be considered a Winkler Region III or IV, depending on annual variation in weather (9). Characteristics of 'Zinfandel' and 'Primitivo' grapevine selections differed between these regions, showing the potential importance of regional data for making recommendations on planting material (5, 10). Thus, the objective of this research was to

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evaluate the performance of six selections of 'Cabernet Sauvignon', including selection 8 as a standard, in Fresno County, California.

Materials and Methods

Own-rooted, virus-free, grapevine cuttings of 'Cabernet Sauvignon' selections FPS 2, 8, 10, 21, 22, and 24, were obtained from FPS (Table 1) and planted in April, 1997, to a vineyard at the Kearney Agricultural Center, Parlier, California. Selections were planted in a randomized, complete block design with ten single-vine replicates. Vines were spaced about 2.3 m within rows, and 3 m between rows. Within-row spacing was wider than normal to facilitate discrimination of the single-vine plots. The vineyard soil was classified as a Hanford fine sandy loam with a rooting depth of about 1.5 m (7).

Table 1. Foundation Plant Services (FPS) selection numbers and source of 'Cabernet Sauvignon' grapevine selections.

FPS No.	Source
2	Oakville, California 11V1
8	Concannon, California 34V2 (#102)
10	Neustadt, Germany PI 258987-A-1
21	Cachapoal, Chile PI 364302
22	Napa, California, Battuello vineyard
24	Sonoma, California, Laurel Glen vineyard

The second winter after planting, each grapevine was pruned to two canes that were retained as permanent bilateral cordons. Cordons were supported by a single wire mounted on a trellis at 1.35 m above the vineyard floor. The trellises also had one foliar catch wire about 0.30 m above the cordon wire. Shoot thinning was performed the following spring, leaving 8 to 9 shoots per m cordon for permanent spur positions. Each subsequent winter, vines were spur-pruned, leaving sixteen to eighteen two-node spurs per vine. Flower clusters were counted after shoot thinning, in spring 2000, and every year thereafter until 2003, the last season data were collected.

All vines, regardless of selection, were harvested on the same day, though harvest dates differed each year: 22 September 2000, 31 August 2001, 27 September 2002, and 19 September 2003. At each harvest, 100 berries per vine were randomly collected, weighed, and macerated in a blender. Soluble solids from the filtered juice were measured with a temperature-compensating digital refractometer (Palette 101, Atago, Farmingdale, NY). Juice pH was measured with a meter (SA720, Orion Research, Inc., Boston, Mass.) and titratable acidity was determined by titration with 0.133 N NaOH to an 8.20 end point using an automatic titrator (900A, Orion Research Inc., Boston, Mass). Then, the clusters on each vine were harvested and weighed. Sour rot incidence was recorded as described previously (5) and cluster weight, and the number of berries per cluster were calculated.

In 2002, anthocyanin concentrations in berry skins were measured. Fifty randomly collected berries per treatment replicate were peeled using scalpels and forceps. The skins were rinsed with distilled water, blotted dry, and one skin disc was collected from each berry with a 3 mm diameter cork borer. Each sample of skin discs was weighed and then frozen in liquid nitrogen, and stored at -20 °C until processing. Then the skin discs were extracted with methanol ($1 \cdot 10^{-2}$ L per g skin), in darkness, for 12 hours. A $1 \cdot 10^{-2}$ L aliquot of each sample was acidified by adding 1% HCl (v/v) and the absorbance of that aliquot, at 520 nm, was determined about 0.5 h later using a spectrophotometer (Milton Roy Co., Rochester, NY). Acidified methanol was used as a blank for the measurements.

All data were subjected to analysis of variance using the GLM procedure of SAS software (SAS Institute, Inc., Cary, NC, USA). Block, year, block by year interaction, and

block by treatment interaction were considered random effects. Variables having significant treatment by year interactions were analyzed separately by year, otherwise the data were combined across years. When treatment effects were significant ($P<0.05$), treatment means were separated by Duncan's New Multiple Range Test.

Results and Discussion

Yield and yield components (cluster wt, berries per cluster, clusters per vine, and berry wt) clearly differed between some years, but there were no selection by year interactions (Table 2). Selections 8, 21, and 22 produced more than 15% higher yields than selections 2, 10, and 24 (Table 2). The number of clusters per vine was variable and, if $\alpha = 0.05$, did not differ between selections (Table 2). However, using a slightly less conservative measure, $\alpha = 0.06$, selection 22 bore more clusters than selection 2 (Table 2). Differences in cluster wt between clones were not clear-cut but, in general, the highest yielding selections had larger clusters than the lowest yielding selections (Table 2). Clusters of each selection had similar numbers of berries (Table 2), so differences in cluster wt were mainly due to differences in berry wt.

The clusters of 'Cabernet Sauvignon' are not prone to sour rot, and sour rot incidence was generally less than 1% in this study. Even so, selection 2 had fewer rotted clusters than did selection 21 (0.11 and 1.89 rotted clusters per vine, respectively), perhaps a consequence of their different berry sizes. Clusters having small berries might be less susceptible to sour rot than clusters having large berries if the larger berries increase contact between adjoining berries resulting in a so-called 'tight' cluster (6). The relatively small berries of selection 2 might also be of

Table 2. Yield and yield components of 'Cabernet Sauvignon' grapevine selections, Parlier, California, 2000-2003.

Year and selection	Yield/vine (kg)	Cluster wt (g)	Berries/cluster (no.)	Clusters/vine (no.)	Berry wt (g)
Year					
2000	18.9 bz	171.7 c	123 b	109 b	1.40 c
2001	16.3 c	247.5 b	181 a	68 d	1.36 d
2002	23.0 a	173.1 c	117 b	135 a	1.48 b
2003	22.7 a	295.1 a	192 a	77 c	1.53 a
Selection					
2	17.36 b	205.5 c	153	88 b	1.34 d
8	21.24 a	225.8 abc	151	99 ab	1.50 a
10	19.25 b	215.0 bc	148	96 ab	1.44 b
21	21.72 a	244.2 a	164	98 ab	1.49 ab
22	23.00 a	232.0 ab	154	104 a	1.51 a
24	19.14 b	210.0 bc	152	100 a	1.38 c
Significance					
Year (Y)	<0.01	<0.01	<0.01	<0.01	<0.01
Selection (S)	<0.01	0.01	0.32	0.06	<0.01
Y • S	0.90	0.94	0.87	0.61	0.83

[z]Means, within year, selection, and columns, followed by different letters are significantly different according to Duncan's New Multiple Range Test, $P < 0.05$.

Table 3. Soluble solids and titratable acidity of grape juice from different 'Cabernet Sauvignon' grapevine selections, Parlier, California, 2000-2003.

	Soluble solids (°Brix)					Titratable acidity (g/L)				
Selection	2000	2001	2002	2003	4-yr avg.	2000	2001	2002	2003	4-yr avg
2	21.8 az	22.2 c	24.2	22.5 c	22.8 b	4.50	5.23	4.44	4.08 a	4.56 a
8	21.2 ab	22.5 abc	24.7	23.6 ab	23.0 b	4.49	5.18	4.41	3.77 bc	4.46 ab
10	20.7 b	22.8 ab	24.2	23.8 ab	22.9 b	4.48	5.09	4.53	3.70 bc	4.45 ab
21	20.8 b	23.4 a	24.1	23.4 b	22.8 b	4.46	5.10	4.55	3.79 bc	4.48 ab
22	21.4 ab	22.9 ab	24.9	24.0 a	23.3 a	4.51	5.00	4.38	3.62 c	4.38 b
24	21.9 a	22.6 abc	24.5	23.4 ab	23.1 ab	4.42	5.23	4.53	3.81 b	4.51 a
Significance, main effects or interactions										
Year (Y)					<0.01					<0.01
Selection (S)	0.03	0.03	0.11	<0.01	<0.01	0.88	0.49	0.36	<0.01	<0.01
Y • S					<0.01					0.03

[z]Means, within columns, followed by different letters are significantly different according to Duncan's New Multiple Range Test, $P < 0.05$.

interest to winemakers if the decreased berry size enhances the proportion of skin to pulp. These findings confirm those of previous studies in the northern San Joaquin Valley, where selections 8 (1) and 21 were higher yielding than 2, and 21 was higher yielding than selection 10 (11). Research in Australia also identified 'Cabernet Sauvignon' selections that consistently produced above-average yields (4). Our data suggest that differences in yield were due more to cluster weight than to cluster number, in agreement with Wolpert et al. (11). In contrast, Bowen and Kliewer (1) attributed the high yield of FPS 8 to its greater number of clusters, but the vines in that study were pruned to canes instead of spurs. Together, the studies show that differences in cropping potential between some 'Cabernet Sauvignon' selections are consistent even when grown in different regions and when subjected to different pruning methods.

Differences between selections with respect to juice soluble solids and to titratable acidity depended on the year ($p < 0.001$ and $p = 0.03$, respectively), so those data are displayed by year (Table 3). Even though soluble solids were quite variable, and differences between selections were usually slight, selections 22 and 24 had the highest soluble solids level at harvest in most years and thus could be considered the selections with the earliest fruit maturity. Conversely, the fruits of selection 2 often were the last to mature as evidenced by their consistently lower juice soluble solids compared to the other selections. These generalities are strengthened by the titratable acidity data; the fruit of selection 22 had, on average, lower titratable acidity than the fruit of selection 2 (Table 3). Differences in juice pH were slight, but selection 22 had a higher juice pH than did selection 10, regardless of year (Table 4). Each selection had a similar anthocyanin concentration in their berry skins (Table 4).

Our fruit composition data agree with those of others (4, 11) who noted minor differences in fruit composition between 'Cab-

Table 4. Juice pH and anthocyanin concentration of berry skins, from 'Cabernet Sauvignon' grapevine selections, Parlier, California, 2000-2003.

Year and selection	pH	Anthocyanin concentration (mg • cm^{-2})
Year		
2000	3.66 c[z]	-[y]
2001	3.64 d	-
2002	3.88 b	0.31
2003	3.93 a	-
Selection		
2[y]	3.79 ab	0.31
8	3.77 bc	0.30
10	3.76 c	0.34
21	3.78 abc	0.30
22	3.81 a	0.31
24	3.79 ab	0.31
Significance		
Year (Y)	<0.01	na[x]
Selection (S)	0.04	0.22
Y • S	0.21	na

[z]Means, within year, selection, and columns, followed by a different letter are significantly different according to Duncan's New Multiple Range Test, P < 0.05.
[y]Data not collected.
[x]na=not applicable

ernet Sauvignon' selections. Wolpert et al. (11) found that the lowest yielding clones tended to mature the earliest, but that was not necessarily true in our study. However, their finding that selection 10 had the lowest juice pH agrees with our data.

In conclusion, differences between the selections tested were rather small, but the high yield and early maturity of selection 22 was distinctive. Vines of the standard selection, 8, also had good yields, as they are known for, but their fruit matured later than those of selection 22.

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