AMERICAN VINEYARD FOUNDATION

Final Report June 1993

PROJECT TITLE: Influence of rootstock and vine spacing on root distribution, vine growth, crop yield, fruit and wine composition, canopy microclimate and wine quality of Cabernet Sauvignon.

PRINCIPAL INVESTIGATORS: W. M. Kliewer

EXECUTIVE SUMMARY

In 1991 and 1992, the effect of seven rootstocks (AxR#1, 110R, 5C, 3309, 420A, 1616, and 039-16) grafted to Cabernet Sauvignon in combination with three between row spacings (2, 3, and 4 m) and two in-row spacings (1 and 2 m) on root and shoot growth, water utilization, leaf, fruit and wine composition, crop yield and wine quality were evaluated in a field plot trial established at the Oakville Experimental Vineyard in 1987.

The data revealed that the above seven rootstocks can be divided into three groups based on rooting depth, pruning weights and crop yield. 110R, AxR, and 039-16 rootstocks had the deepest roots, made the most vegetative growth and had the highest crop yield; 5C, 3309, and 1616 were intermediate in growth and yield, and 420A had the least amount of shoot growth and lowest yield. Neutron probe measurements also showed that AxR, 039-16, and 110R were able to utilize water down to depths of 210 cm (~7 ft); 3309, 5C, and 1616 mainly used water at depths between 30 and 150 cm and 420A mostly used water at depths less than 120 cm. In another field trial comparing St. George, AxR, and 110R it was shown that St. George had greater root density and deeper roots than 110R and AxR#1.

There were relatively little differences in fruit composition at harvest between the seven rootstocks. 039-16 consistently had the highest pH, K^+, and malic acid of the seven rootstocks. 110R fruit was the first to ripen and had the highest titratable acidity and anthocyanin pigment per berry, however, on a per gram basis, the level of anthocyanin did not differ significantly between rootstocks. In leaf petiole analyses, 039-16 had the highest level of K^+, Ca^{++}, NO_3^-, and Ca/mg ratio, and 420A was consistently the lowest in K at both bloom and veraison.

The average crop yield of vines from rows spaced 2, 3, and 4 m apart was 7.7, 5.9, and 5.1 tons/ac, respectively, and for in-row spacings of 1 and 2 m, 7.0 and 5.5 tons/ac, respectively. Fruits from vines spaced 3 and 4 m apart between rows were significantly higher in sugar and pH than 2 m row spacing, however, TA, malic acid, K, and anthocyanin in fruits did not differ between row spacing treatments. Fruits from vines spaced 1 m apart within rows were significantly higher in pH, K, malic acid, and anthocyanin/berry than fruits from vines spaced 2 m apart.

Wines made from Cabernet Sauvignon grafted onto different rootstocks differed in composition. 039-16 wines had the highest pH and hue and less red and total coloration than 5C, 3309 and 110R. 5C wine had the lowest pH and hue and the highest level of anthocyanin and total coloration of the above four stocks. Wines made from vines at two meter spacing generally had higher titratable acidity and level of anthocyanin than four meter row spacing wines. Within row vine spacing had little effect on wine composition. Duo-trio tasting of wines made from the 1992 vintage showed that 5C and 3309 wines could generally be distinguished from 110R and 039-16 wines. 5C wine had the most fruity character, whereas 110R and 039-16 wines were more vegetative and astringent in character. 3309 wine had the most herbal/spicy character of the four rootstocks. For 5C rootstock, closer vine spacing (2 x 1 and 2 x 2 m) wines could be distinguished from wider vine spacing (4 x 1 and 4 x 2 m) with a preference for the closer vine spacing wines. However, for 110R rootstock, wines did not differ between row and vine spacing in duo-trio taste comparisons.

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PRINCIPAL INVESTIGATORS:

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OBJECTIVES:

1. Determine the influence of rootstock and vine spacing on distribution, depth and pattern of rooting of Cabernet Sauvignon grapevines.

2. Determine the influence of rootstock and vine spacing on vine growth and the relative amounts of soil water utilized by Cabernet Sauvignon vines per acre.

3. Determine the effects of rootstocks and vine spacing on crop yield and yield components of Cabernet Sauvignon grapevines.

4. Determine the effects of rootstocks and vine spacing on mineral and organic constituents of leaves, fruits, and wines of Cabernet Sauvignon grapevines.

5. Determine the effects of rootstocks and vine spacing on wine sensory properties as measured by taste panels and descriptive sensory analysis.

SUMMARY:

In 1991 and 1992, the effect of seven rootstocks (AxR#1, 110R, 5C, 3309, 420A, 1616, and 039-16) grafted to Cabernet Sauvignon in combination with three between row spacings (2, 3, and 4 m) and two in-row spacings (1 and 2 m) on root and shoot growth, water utilization, leaf, fruit and wine composition, crop yield and wine quality were evaluated in a field plot trial established at the Oakville Experimental Vineyard in 1987.

The 1991 and 1992 data revealed that the above seven rootstocks can be divided into three groups based on rooting depth, pruning weights and crop yield. 110R, AxR, and 039-16 rootstocks had the deepest roots, made the most vegetative growth and had the highest crop yield; 5C, 3309, and 1616 were intermediate in growth and yield, and 420A had the least amount of shoot growth and lowest yield. Neutron probe measurements also showed that AxR, 039-16, and 110R were able to utilize water down to depths of 210 cm (~7 ft); 3309, 5C, and 1616 mainly used water at depths between 30 and 150 cm and 420A mostly used water at depths less than 120 cm. In another field trial comparing St. George, AxR, and 110R it was shown that St. George had greater root density and deeper roots than 110R and AxR#1.

There were relatively little differences in fruit composition at harvest between the seven rootstocks. 039-16 consistently had the highest pH, K^+, and malic acid of the seven rootstocks. 110R fruit was the first to ripen and had the highest titratable acidity and anthocyanin pigment per berry, however, on a per gram basis, the level of anthocyanin did not differ significantly between rootstocks. In leaf petiole analyses, 039-16 had the highest level of K^+, Ca^{++}, NO_3^-, and Ca/mg ratio, and 420A was consistently the lowest in K at both bloom and veraison.

The average crop yield of vines from rows spaced 2, 3, and 4 m apart was 7.7, 5.9, and 5.1 tons/ac, respectively, and for in-row spacings of 1 and 2 m, 7.0 and 5.5 tons/ac, respectively. Fruits from vines spaced 3 and 4 m apart between rows were significantly higher in sugar and pH than 2 m row spacing, however, TA, malic acid, K, and anthocyanin in fruits did not differ between row spacing treatments. Fruits from vines spaced 1 m apart within rows were significantly higher in pH, K, malic acid, and anthocyanin/berry than fruits from vines spaced 2 m apart.

Wines made from Cabernet Sauvignon grafted onto different rootstocks differed in composition. 039-16 wines had the highest pH and hue and less red and total coloration than 5C, 3309 and 110R. 5C wine had the lowest pH and hue and the highest level of anthocyanin and total coloration of the above four stocks. Wines made from vines at two meter spacing generally had higher titratable acidity and level of anthocyanin than four meter row spacing wines. Within row vine spacing had little effect on wine composition. Duo-trio tasting of wines made from the 1992 vintage showed that 5C and 3309 wines could generally be distinguished from 110R and 039-16 wines. 5C wine had the most fruity character, whereas 110R and 039-16 wines were more vegetative and astringent in character. 3309 wine had the most herbal/spicy character of the four rootstocks. For 5C rootstock, closer vine spacing (2 x 1 and 2 x 2 m) wines could be distinguished from wider vine spacing (4 x 1 and 4 x 2 m) with a preference for the closer vine spacing wines. However, for 110R rootstock, wines did not differ between row and vine spacing in duo-trio taste comparisons.

RESEARCH ACCOMPLISHMENTS:

Objective 1: Determine the influence of rootstock and vine spacing on distribution, depth and pattern of rooting of Cabernet Sauvignon grapevines.

Neutron probe measurements of water utilization by seven different rootstocks in 1992, showed that 110R, 039-16, and AxR rootstocks utilized more water at deeper depths (> 120 cm) than 1616, 3309, and 420A, with 5C intermediate (Fig. 1). 110R rootstock utilized more water between depths of 120 to 150 cm than 3309. 3309 took up the maximum amount of water at depths between 90 and 120 cm and also utilized water down to 90 cm depth midway between vine rows spaced 3 m apart, whereas 110R utilized water at depths greater than 120 cm in close proximity to the vine trunk,

and less water midway between the vine rows. These data suggest that 3309 is more shallow rooted than 110R and tends to extend its roots more laterally, whereas 110R extends roots more vertically. The rootstocks 110R, 039-16, AxR, and 5C were all able to utilize water down to a depth of 210 cm (~ 7 ft), whereas 3309, 420A and 1616 utilized little water below 120 cm (4 ft).

Objective 2: Determine the influence of rootstock and vine spacing on vine growth and the relative amounts of soil water utilized by Cabernet Sauvignon vines per acre.

The data in Tables 1 and 3 shows that 110R, AxR, and 039-16 produced the greatest amount of pruning weight and weight per shoot, 1616, 5C and 3309 were intermediate and 420A had the least amount of growth. Spur shoots from 110R and AxR were longest, 420A shoots were the shortest and the other stocks intermediate. Leaf area per gram of fruit was similar in all stocks, except 420A, which was significantly higher than the other six stocks.

Increasing the distance between rows and between vines within rows increased the amount of pruning weight per vine, as would be expected (Table 4). Shoots from vines in rows spaced 4 m apart were significantly longer and heavier than in vines from rows spaced 2 and 3 m apart (Table 4). Leaf area per shoot and per vine was also greater in vines from rows spaced 4 m apart compared to 2 and 3 m row spacing. Wider spacing between vines within rows also increased total leaf area per vine, but not the average leaf area per shoot.

Soil moisture from 2 m row spacing and 1 m vine spacing was always less at all depths than in 3 and 4 m row spacing and 2 m vine spacing (Figs. 2 and 3). The rootstocks 110R, 039-16, AxR, and 5C utilized the most water at all depths down to 210 cm and 3309, 1616, and 420A used the least amount of water (Fig. 1, and Table 2). There was a direct positive correlation between the amount of top growth (leaf area) and the amount of water depleted from the soil profile.

Objective 3: Determine the effects of rootstocks and vine spacing on crop yield and yield components of Cabernet Sauvignon grapevines.

AxR, 110R, and 039-16 produced the highest crop yield (7 to 7.4 tons/ac), 420A the least (3.4 tons/ac) and 1616, 5C, and 3309 stocks were intermediate in yield (5.8 to 6.3 tons/ac). The higher crop yields were mainly due to greater number of clusters per vine and berries set per cluster with relatively little difference in berry weight (Table 6).

The average crop yield from rows spaced 2, 3, and 4 m apart was 7.7, 5.9, and 5.1 tons/ac, respectively, and for in-row vine spacing of 1 and 2 m, 7.0 and 5.5 tons/ac, respectively (Table 7). The higher yields obtained from closer spacings was due to greater number of clusters produced per acre. Berry weight, cluster weight and berries per cluster increased with an increase in row width, however, berry weight was greater at 1 m in-row vine spacing than at 2 m spacing (Table 7).

Objective 4: Determine the effects of rootstocks and vine spacing on mineral and organic constituents of leaves, fruits and wines of Cabernet Sauvignon grapevines.

The fruit composition of the seven rootstocks sampled on September 7, 1992, and at harvest, are presented in Tables 8 and 9. There were relatively little differences in fruit composition between rootstocks at harvest. 110R and 5C fruits were the earliest to ripen; AxR, 1616, and 420A fruits ripened intermediately, and 039-16 and 3309 fruits were the latest to ripen, however all fruits from the

different rootstocks ripened to the same °Brix within five days. Fruits from 039-16 consistently had the highest pH, K^+, and malate of the seven rootstocks. At harvest, there were no significant differences in °Brix, pH, TA, and anthocyanin in berry skins between the seven rootstocks.

There were considerable differences in the level of minerals in leaf petioles between rootstocks (Table 11). 039-16 stood out as having the highest level of K, Ca, NO_3, and Ca/Mg ratio and 420A was consistently the lowest in K at both bloom and veraison (Table 11). The mineral content of petioles of AxR, 110R, 1616, and 5C were similar.

Fruits from vines spaced 1 m apart within rows were significantly higher in pH, K, malate, and TA than fruits from vines spaced 2 m apart, however, the level of sugar and anthocyanin in fruits did not differ between vine spacing (Table 10). Row spacing had relatively little effect on fruit composition. Fruits from wider row spacings (4 m) were higher in TA and lower in pH than narrow row spaced fruits (2 and 3 m). Row spacing had no significant effect on the mineral content of leaves. The level of K and NO_3 in petioles of vines spaced 1 m apart were higher and Ca and Mg were lower than in vines spaced 2 m apart.

Objective 5: Determine the effect of rootstocks and vine spacing on wine sensory characteristics.

In duo-trio difference tastings of four rootstocks (3309, 110R, 420A, and 039-16) at two vine x row spacings (2 x 2 and 2 x 3 m) there was no significant difference between the four rootstock wines made from the 1991 vintage, however, 3309 wines received the greatest number of first place votes and 039-16 placed last (Table 13). For 3309, wines produced from 2 x 2 vine x row spacing was preferred over 2 x 3 m spacing.

Replicated wines were made from four of the rootstocks (5C, 3309, 110R and 039-16), and four row x vine spacing combinations (2 x 1 m, 2 x 2 m, 4 x 1 m, and 4 x 2 m) from the 1992 vintage and compared by duo-trio tastings (Tables 14 to 17).

Wine analyses of the four rootstocks revealed that 039-16 had significantly higher pH and hue and lower total color than 5C, 3309, and 110R (Table 14). Duo-trio tastings of wines made from these same four stocks showed that 5C and 3309 could be distinguished from 110R, but not from each other (Table 15). 5C also differed from 039-16, however 039-16 and 110R and 3309 and 039-16 did not differ when compared by duo-trio tastings. Comments of judges quite consistently revealed that 5C wines had more fruity characteristic than the other three rootstocks. 110R and to a lesser degree 039-16 wines had more astringent/bitterness characteristics than 5C and 3309 (Table 16). A majority of judges also commented that 110R wines had some "off" odors and some vegetative characteristics. 3309 wines tended to have the most herbal-spicy character (Table 16).

Wines from 5C and 110R were also compared at four different row x vine spacing combinations (Table 17). Wines made from 5C rootstock at closer row x vine spacing (2 x 1 and 2 x 2 m) could generally be distinguished from wider spacings (2 x 2, 4 x 1, and 4 x 2 m), however, wines made from 110R rootstock did not differ significantly between row x vine spacing combinations (Table 17).

TABLE 1 INFLUENCE OF ROOTSTOCK ON SHOOT GROWTH, PRUNING WEIGHT AND YIELD/PRUNING WEIGHT RATIO OF CABERNET SAUVIGNON GROWN AT THE OAKVILLE EXPERIMENTAL VINEYARD*. 1992 DATA.

	Cane Shoots			Spur Shoots				Pruning Wt		
Rootstock*	Total Length (cm)	Internode Length (cm)	No. Nodes per shoot	Total Length (cm)	Internode Length (cm)	No. Nodes per shoot	Average Shoot Wt per vine (g)	Kg/vine	Kg/m	Yield/ Pruning Wt. Ratio
AxR	74	4.1	18	172	5.5	31	49	1.49	1.06	4.71
039-16	66	3.9	17	157	5.4	29	46	1.29	0.92	4.97
110R	76	4.2	18	178	5.7	31	49	1.49	1.05	5.12
1616	71	3.9	18	166	5.5	30	40	1.10	0.77	5.30
5C	66	3.9	17	151	5.4	28	40	1.07	0.76	5.60
3309	66	3.9	17	145	5.2	28	42	1.15	0.82	5.29
420A	66	3.9	17	129	4.8	27	34	0.67	0.49	4.97
Signif Level	NS	--	NS	0.002	---	0.03	0.01	0.0001	0.0001	NS

* Rootstock data represents means of three between row spacings (2, 3, and 4 m) and two within row spacings (1 and 2 m). In 1992, the vines were five-years-old (planted in 1987).

TABLE 2 INFLUENCE OF ROOTSTOCK ON THE PERCENT VOLUME SOIL MOISTURE AT VARIOUS SOIL DEPTHS AT FOUR DIFFERENT DATES

1992 Oakville Block B Rootstock Trial

Effect of Rootstock on Percent Volume Soil Moisture

At End of Periods Without Irrigation

	AxR	110R	1616	5C	3309	420A	039-16	Signif Level Between Stocks (1)
7/17/92 (Previous Irrigation = 8 gal on 6/24/92)								
30cm	19.9	18.8	19.7	19.9	19.8	20.4	19.5	ns
60cm	20.1	17.2	20.1	19.5	21.3	23.9	20.4	.0009
90cm	19.1	17.5	19.8	18.9	21.7	25.5	19.6	ns
120cm	20.6	19.3	21.8	19.0	22.3	25.9	21.3	.09
150cm	23.1	21.9	25.0	22.3	24.3	26.0	22.3	ns
180cm	24.7	23.2	25.1	24.1	25.3	24.7	23.6	ns
210cm	26.7	24.8	23.7	27.0	26.1	30.2	25.5	.04
7/29/92 (Previous Irrigation = 5 gal on 7/17/92)								
30cm	19.4	18.3	19.6	19.7	19.7	19.8	19.1	ns
60cm	20.2	17.6	19.6	19.1	20.5	23.5	19.9	ns
90cm	18.9	17.6	19.5	18.7	21.3	25.2	19.3	ns
120cm	20.2	18.6	21.3	18.5	21.7	26.2	20.4	.04
150cm	22.2	21.2	22.9	21.4	23.4	25.3	21.3	ns
180cm	23.3	22.0	24.7	22.9	24.8	25.5	22.5	ns
210cm	25.8	25.0	24.1	26.6	28.0	30.7	26.0	ns
8/05/92 (Previous Irrigation - 5 gal on 7/17/92)								
30cm	19.4	18.2	19.0	19.4	19.3	19.9	18.8	ns
60cm	19.8	17.5	19.3	19.0	20.5	23.6	19.8	.03
90cm	18.7	17.3	19.3	18.4	20.6	25.2	19.2	ns
120cm	20.1	18.5	21.1	18.3	21.4	25.8	20.0	.03
150cm	21.9	20.5	23.2	21.3	23.0	24.6	20.8	ns
180cm	22.9	21.6	23.6	22.8	24.4	25.1	22.4	ns
210cm	25.3	24.1	22.6	25.8	26.3	31.3	24.4	ns
8/20/92 (Previous Irrigation - 18 gal on 8/06/92)								
30cm	19.6	18.3	18.5	19.6	18.9	20.0	18.9	ns
60cm	19.8	17.1	18.5	19.1	18.6	20.7	19.8	.005
90cm	18.6	17.3	18.6	18.3	18.5	20.4	19.0	ns
120cm	19.9	18.2	19.8	18.2	20.2	22.1	19.9	.04
150cm	21.8	20.5	22.0	20.9	22.8	23.2	20.4	ns
180cm	22.6	21.1	23.8	22.2	23.7	25.6	21.7	ns
210cm	25.3	24.3	25.9	26.1	26.1	28.3	24.4	ns
Average								
30cm	19.6	18.4	19.3	19.6	19.6	20.0	19.1	ns
60cm	20.0	17.4	19.5	19.2	20.7	23.6	20.0	.01
90cm	18.8	17.4	19.5	18.6	21.1	25.3	19.3	ns
120cm	20.2	18.7	21.2	18.5	21.6	25.6	20.4	.04
150cm	22.2	21.0	23.3	21.5	23.3	25.3	21.2	ns
180cm	223.4	22.0	24.2	23.0	24.6	25.0	22.6	ns
210cm	25.8	24.5	23.3	26.4	26.8	31.0	25.1	.09

(1) Rootstock 420A received supplemental irrigation and was therefore not included in the statistical evaluation.

Note: Recalculated using new neutron probe standardization February 22, 1993

TABLE 3 INFLUENCE OF ROOTSTOCK ON THE AMOUNT OF LEAF AREA PER SHOOT, PER VINE AND LEAF AREA/FRUIT WEIGHT RATIO FOR THE 1992 SEASON.

Rootstock	Spur Shoots			Cane Shoots		
	Primary Leaf Area/Shoot (cm^2)	Lateral Leaf Area/Shoot (cm^2)	% Total Leaf Area From Lateral Shoots	Primary Leaf Area/Shoot (cm^2)	Total Leaf Area Per Vine (m^2)	Leaf Area Crop Wt/Ratio
AxR	3180	843	20.9	1428	6.89	11.0
039-16	2945	779	20.9	1288	5.98	11.0
110R	3303	867	20.8	1470	7.03	11.3
1616	3093	833	21.2	1381	6.30	11.1
5C	2834	636	18.3	1285	5.49	10.3
3309	2738	542	16.5	1290	5.44	11.6
420A	2445	645	20.9	1288	4.22	15.8
Signif. Level	0.001	0.08	0.01	NS	0.0001	0.006

TABLE 4 INFLUENCE OF ROW AND VINE SPACING ON SHOOT GROWTH, PRUNING WEIGHT, AND YIELD/PRUNING WEIGHT RATIO OF CABERNET SAUVIGNON GROWN AT THE OAKVILLE EXPERIMENTAL VINEYARD. 1992 DATA.

	Cane Shoots			Spur Shoots				Pruning Wt		
Spacing Treatment	Total Length (cm)	Internode Length (cm)	Total Nodes Per Shoot	Total Length (cm)	Internode Length (cm)	No. Nodes Per Shoot	Average Shoot Wt Per Vine (g)	Kg/vine	Kg/m	Yield/ Pruning Wt. Ratio
Row Spacing*										
2 m	67	3.9	17	158	5.6	28	40	1.07	0.76	4.88
3 m	65	3.8	17	149	5.1	29	40	1.14	0.81	5.32
4 m	75	4.0	19	163	5.4	30	48	1.33	0.94	5.21
Signif Level	0.02	---	0.02	NS	---	NS	0.06	0.02	0.01	NS
Vine Spacing*										
1 m	71	4.1	17	162	5.6	29	45	1.00	1.00	4.90
2 m	67	3.7	18	152	5.2	29	41	1.36	0.68	5.37
Signif Level	NS	---	NS	0.02	---	NS	0.01	0.0001	0.0001	0.06

* Row and vine spacing data represent the means of seven different rootstocks composited together. In 1992, the vines were five-years-old (planted in 1987).

TABLE 5 INFLUENCE OF ROW AND VINE SPACING ON THE AMOUNT OF LEAF AREA PER SHOOT, PER VINE, AND LEAF AREA/FRUIT WEIGHT RATIO FOR THE 1992 SEASON.

Spacing Treatments	Spur Shoots			Cane Shoots	Total Leaf Area Per Vine	Leaf Area Crop Wt/Ratio
	Primary Leaf Area/Shoot (cm^2)	Lateral Leaf Area/Shoot (cm^2)	% Total Leaf Area From Lateral Shoots	Primary Leaf Area Per Shoot (cm^2)		
Row Spacing						
2 m	2957	716	19.5	1309	5.72	12.9
3 m	2801	664	23.7	1261	5.54	11.3
4 m	3045	825	21.3	1471	6.45	11.0
Signif Level	NS	NS	NS	0.02	0.08	NS
Vine Spacing						
1 m	3025	799	20.9	1383	5.26	12.9
2 m	2843	671	19.1	1312	6.55	10.5
Signif Level	0.02	0.02	NS	NS	0.0001	0.0001

TABLE 6 INFLUENCE OF ROOTSTOCK ON CROP YIELD, YIELD COMPONENTS, SUNBURN DAMAGE AND AMOUNT OF RACHIS COLLAPSE DAMAGE OF CABERNET SAUVIGNON GROWN AT THE OAKVILLE EXPERIMENTAL VINEYARD. 1992 DATA.

Rootstock*	No. Clusters Removed Per Vine**	No. Clusters Retained Per Vine	Berry Wt (g)	Cluster Wt (g)	No. Berries per cluster	Crop Yield	
						Kg/vine	Tons/ac
AxR	12	44	1.17	155	132	6.9	7.6
039-16	14	42	1.23	155	127	6.5	7.0
110R	14	46	1.19	150	126	6.8	7.4
1616	14	37	1.15	153	133	5.7	6.2
5C	12	39	1.21	147	122	5.8	6.3
3309	13	41	1.13	132	117	5.4	5.8
420A	7	20	1.15	141	122	3.0	3.4
Signif Level	0.0001	0.0001	0.06	0.004	0.008	0.0001	0.0001

*Rootstock data represents means of three between row spacings (2, 3, and 4 m) and two within row spacings (4 and 2 m). In 1992 the vines were five-years-old (planted in 1987).

**Clusters were thinned on July 21, 1992, such that shoots < 21 cm carried no clusters, shoots from 21 cm to 35 cm long carried one cluster and shoots > 35 cm carried two clusters.

TABLE 7 INFLUENCE OF ROW AND VINE SPACING ON CROP YIELD, YIELD COMPONENTS, SUNBURN DAMAGE AND AMOUNT OF RACHIS COLLAPSE DAMAGE OF CABERNET SAUVIGNON GROWN AT THE OAKVILLE EXPERIMENTAL VINEYARD. 1992 DATA.

Spacing Treatments*	No. Clusters Removed Per Vine**	No. Clusters Retained Per Vine	Berry Wt (g)	Cluster Wt (g)	No. Berries Per Cluster	Crop Yield	
						Kg/Vine	Tons/Ac
Row Spacing							
2 m	13	37	1.12	134	120	5.0	7.7
3 m	12	37	1.18	148	125	5.6	5.9
4 m	12	41	1.23	160	131	6.6	5.1
Signif Level	NS	NS	0.01	0.02	NS	0.004	0.0005
Vine Spacing							
1 m	8	29	1.19	147	124	4.4	7.0
2 m	16	47	1.16	147	127	7.0	5.5
Signif Level	0.0001	0.0001	0.01	NS	NS	0.0001	0.0001

*Row and vine spacing data represent the means of seven different rootstocks composited together. In 1992, the vines were five-years-old (planted in 1987).

**Clusters were thinned on July 21, 1992, such that shoots < 21 cm long carried no clusters, shoots 21 to 35 cm long carried one cluster and shoots > 35 cm long carried two clusters.

TABLE 8 INFLUENCE OF ROOTSTOCK ON THE COMPOSITION OF CABERNET SAUVIGNON FRUIT SAMPLED ON SEPTEMBER 7, 1992

Rootstock	Total Soluble Solids (°Brix)	pH	Titratable Acidity (g/L)	K (ppm)	Malate (g/L)	Anthocyanin	
						mg/berry	mg/g
AxR	22.2	3.28	6.85	1328	1.93	1.15	0.99
039-16	22.2	3.31	6.98	1324	2.27	1.18	0.97
110R	22.6	3.26	7.38	1297	2.16	1.22	1.03
1616	22.2	3.27	7.04	1283	2.02	1.15	1.01
5C	22.3	3.27	6.75	1281	1.93	1.26	1.05
3309	22.2	3.29	6.93	1289	1.97	1.16	1.02
420A	22.7	3.33	6.61	1297	1.74	1.08	0.93
Signif Level	0.08	0.03	0.001	NS	0.001	0.05	0.08

TABLE 9 INFLUENCE OF ROOTSTOCK ON COMPOSITION OF CABERNET SAUVIGNON FRUIT AT HARVEST FROM VINES GROWN AT THE OAKVILLE EXPERIMENTAL VINEYARD. 1992 DATA.

Rootstock	Harvest Date	Total Soluble Solids (°Brix)	pH	Titratable Acidity (g/L)	K ppm	Malate (g/L)	Anthocyanin	
							mg/berry	mg/g
AxR	9/14	23.2	3.31	6.58	1244	1.88	1.23	1.06
039-16	9/15	23.0	3.33	6.88	1398	2.16	1.20	1.00
110R	9/13	23.5	3.32	6.63	1286	2.04	1.22	1.03
1616	9/14	23.3	3.32	6.51	1217	1.97	1.26	1.10
5C	9/13	23.2	3.31	6.66	1262	1.95	1.29	1.08
3309	9/15	23.3	3.32	6.80	1341	1.87	1.10	0.99
420A	9/14	23.5	3.36	6.31	1240	1.70	1.16	1.02
Signif Level		NS	NS	NS	0.0001	0.0001	NS	NS

TABLE 10 INFLUENCE OF ROW AND VINE SPACING ON FRUIT COMPOSITION OF CABERNET SAUVIGNON AT HARVEST. 1992 DATA.

Spacing Treatment*	Total Soluble Soils (°Brix)	pH	Titratable Acidity (g/L)	K (ppm)	Malate (g/L)	Anthocyanin	
						mg/berry	mg/g
Row Spacing							
2 m	23.0	3.34	6.54	1316	1.82	1.17	1.07
3 m	23.4	3.35	6.41	1246	1.96	1.21	1.03
4 m	23.5	3.29	6.92	1290	2.04	1.24	1.02
Signif Level	NS	0.008	0.04	NS	NS	NS	NS
Vine Spacing							
1 m	23.2	3.34	6.66	1297	2.04	1.22	1.03
2 m	23.3	3.31	6.59	1271	1.84	1.20	1.05
Signif Level	NS	0.0001	0.06	0.0008	0.0001	NS	NS

*Row and vine spacing data represent the means of seven rootstocks composited together.

TABLE 11 INFLUENCE OF ROOTSTOCK ON THE LEVEL OF MINERALS IN PETIOLES OF CABERNET SAUVIGNON SAMPLES AT BLOOM AND VERAISON DURING THE 1992 SEASON.

Rootstock	Bloom Petioles					Veraison Petioles				
	% K	% Ca	% Mg	Ca/Mg Ratio	NO_3-N (ppm)	% K	% Ca	% Mg	Ca/Mg Ratio	NO_3-N (ppm)
AxR	1.74	1.61	0.69	2.39	365	2.10	1.58	1.16	1.37	353
110R	1.63	1.72	0.71	2.43	262	2.31	1.54	1.16	1.35	246
1616	1.59	1.56	0.70	2.26	209	1.93	1.66	1.36	1.23	364
5C	1.58	1.57	0.68	2.35	270	2.07	1.63	1.27	1.29	390
3309	2.02	1.36	0.58	2.37	335	2.35	1.35	1.19	1.16	521
420A	1.14	1.51	0.75	2.04	280	1.67	1.71	1.57	1.10	414
039-16	2.58	1.91	0.68	2.85	448	3.25	1.65	1.02	1.66	394
Signif Level	.0001	.0001	.004	.0001	.003	.0001	.0002	.0001	.0001	.0001

TABLE 12 INFLUENCE OF ROW AND VINE SPACING ON THE LEVEL OF MINERALS IN PETIOLES OF CABERNET SAUVIGNON SAMPLED AT BLOOM AND VERAISON DURING THE 1992 SEASON.

Spacing Treatment	Bloom Petioles					Veraison Petioles				
	% K	% Ca	% Mg	Ca/Mg Ratio	NO_3-N (ppm)	% K	% Ca	% Mg	Ca/Mg Ratio	NO_3-N (ppm)
Row Spacing										
2 m	1.90	1.60	0.68	2.40	267	2.42	1.58	1.21	1.35	402
3 m	1.77	1.59	0.67	2.40	282	2.24	1.54	1.26	1.26	386
4 m	1.59	1.63	0.70	2.35	381	2.06	1.64	1.28	1.32	362
Signif Level	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Vine Spacing										
1 m	1.67	1.61	0.69	2.35	315	2.37	1.53	1.20	1.31	413
2 m	1.84	1.60	0.67	2.42	304	2.11	1.65	1.29	1.31	353
Signif Level	.004	NS	NS	NS	NS	.01	.0007	.0003	NS	.008

TABLE 13 TASTING RESULTS FROM CABERNET SAUVIGNON ROOTSTOCK SPACING TRIAL WITH CABERNET SAUVIGNON FOR THE 1991 VINTAGE.

1) DUO-TRIO DIFFERENCE TASTINGS:

Comparison	# Correct	Significance	Stated Preferences
Spacing			
110R; 2x2 vs 2x3 m	10/17	NS	2:1 for 2x3 m
3309; 2x2 vs 2x3 m	13/17	*	3:2 for 2x2 m
Rootstock			
110R vs 039-16	8/14	NS	3:2 for 039-16
110R vs 3309	9/15	NS	3:2 for 3309
420A vs 3309	11/15	NS	4:2 for 420A

2) PREFERENCE-RANKING TASTINGS:

Treatment	Rank	Total Points	First Place	Last Place
2x2 Meter Spacing: Tasted twice, totaling 35 tasters				
3309	1	73a	16	7
110R	2	87a	5	6
420A	3	90a	9	10
039-16	4	100a	6	13
There was one tie for first place and one tie for last place. The 3309 and 039-16 wines were only one point away from significance at the .05 level.				
2x3 Meter Spacing				
3309	1	34a	8	2
420A	2	44a	4	4
110R	3	51a	3	7
039-16	4	51a	3	5
While there was no significance to the ranking tasting results, the 3309 wine placed first and the 039-16 wine placed last in all three ranking tastings.				

TABLE 14 Influence of rootstock and row and vine spacing on composition of wines from 1992 vintage.

Treatment	Ethanol (%)	pH	Titratable Acidity (g/L)	Anthocyanin		Total Color $A_{420} + A_{520}$	Hue A_{420}/A_{520}
				A_{520}	A_{2520} @ pH < 1		
Rootstock							
5C	11.8	3.39	6.4	8.82	27.2	13.2	0.50
110R	12.2	3.46	6.4	8.15	25.3	12.5	0.54
3309	12.0	3.48	6.1	7.86	28.0	12.1	0.54
039-16	12.1	3.61	6.1	6.45	28.1	10.1	0.57
Signif Level	0.03	0.0001	0.0002	0.0001	0.05	0.0001	0.0001
Row Spacing							
2 m	11.8	3.49	6.4	7.98	27.0	12.2	0.54
4 m	12.2	3.48	6.2	7.66	27.4	11.8	0.54
Signif Level	0.0001	NS	0.002	0.04	NS	0.04	NS
Vine Spacing							
1 m	11.9	3.49	6.3	7.93	26.9	12.1	0.53
2 m	12.1	3.48	6.2	7.71	27.4	11.9	0.54
Signif Level	0.01	NS	NS	NS	NS	NS	0.02

TABLE 15 DUO-TRIO TASTING RESULTS FROM CABERNET SAUVIGNON ROOTSTOCK-SPACING TRIAL FOR 1992 VINTAGE, OAKVILLE, CA.

Rootstock Winetasting Comparisons	Vine x Row Spacing	# Correct Responses/ Total # Judges	Signif Level
5C vs 3309	2 x 2 m	17/32	NS
5C vs 039-16	2 x 2 m	24/36	5%
5C vs 110R	2 x 2 m	28/36	0.1%
3309 vs 039-16	2 x 2 m	18/32	NS
3309 vs 110R	2 x 2 m	27/36	1%
039-16 vs 110R	2 x 2 m	17/32	NS

TABLE 16 INCIDENCE OF THE NUMBER OF JUDGES COMMENTS ON HOW THE AROMA AND FLAVOR OF CABERNET SAUVIGNON WINES DIFFERED DEPENDING ON THE ROOTSTOCK USED*

Flavor/Aroma Characteristic	Rootstock			
	5C	3309	039-16	110R
More fruitiness	18	6	6	8
More herbal/spice	5	8	1	5
More vegetativeness/cooked vegetative	2	1	2	7
Off odors	1	3	2	8
High acidity	3	2	1	3
More stringency/bitterness	5	4	10	20

*The incidence of judges comments are from wines where differences were correctly identified. The higher the number, the greater the likelihood that the flavor/aroma characteristic existed.

TABLE 17 DUO-TRIO TASTING RESULTS FROM CABERNET SAUVIGNON ROOTSTOCK-SPACING TRIAL FOR 1992 VINTAGE, OAKVILLE, CA.

Spacing Comparisons (row x vine spacing)	Rootstock	# Correct Responses/ Total # Judges	Signif. Level
2 x 1 vs 2 x 2 m	5C	17/36	NS
2 x 1 vs 4 x 1 m	5C	25/36	5%
2 x 2 vs 4 x 2 m	5C	23/32	5%
4 x 2 vs 4 x 1 m	5C	27/40	5%
2 x 1 vs 2 x 2 m	110R	18/36	NS
2 x 1 vs 4 x 1 m	110R	9/24	NS
2 x 2 vs 4 x 2 m	110R	19/36	NS
4 x 2 vs 4 x 1 m	110R	13/32	NS

FIGURE 1 INFLUENCE OF SIX ROOTSTOCKS ON THE AMOUNT OF SOIL MOISTURE PRESENT AT DIFFERENT DEPTHS MEASURED ON AUGUST 20, 1992, AT THE OAKVILLE EXPERIMENTAL VINEYARD

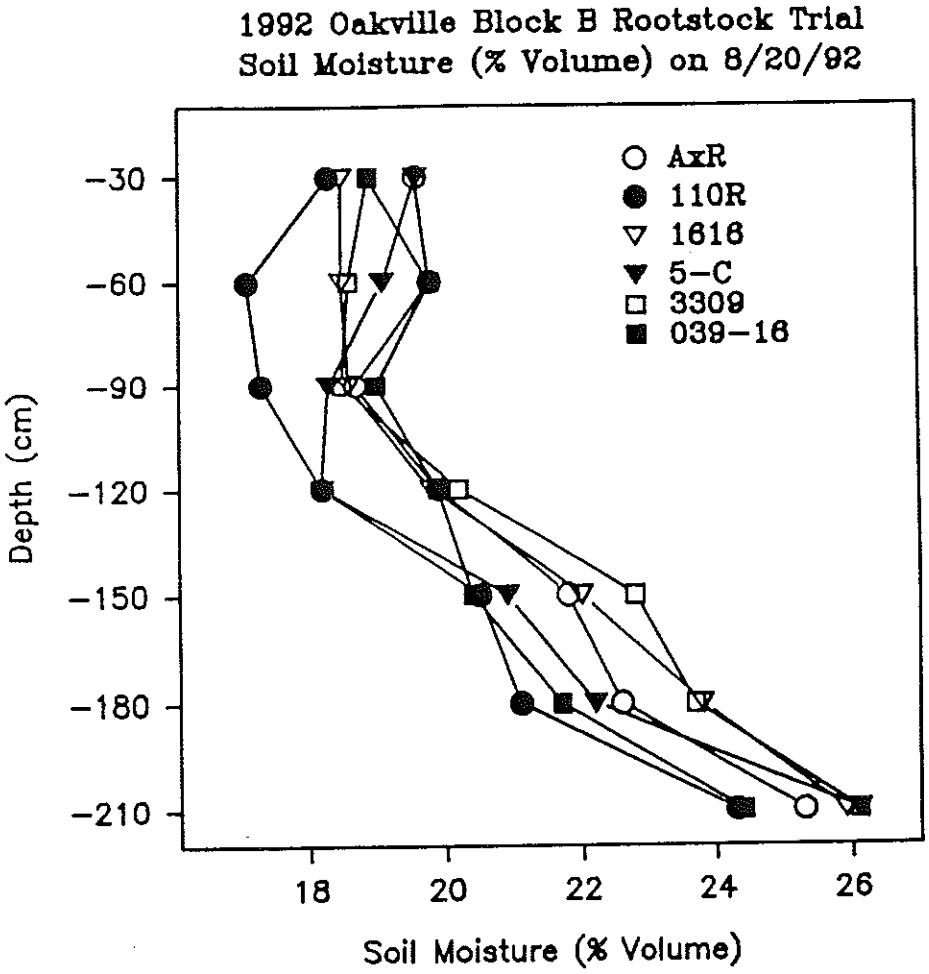


FIGURE 2 INFLUENCE OF ROW SPACING ON THE AMOUNT OF SOIL MOISTURE AT DIFFERENT DEPTHS. DATA IS FOR THE 1992 SEASON. FOR EACH ROW SPACING THE DATA FROM SEVEN ROOTSTOCKS HAS BEEN COMPOSITED TOGETHER.

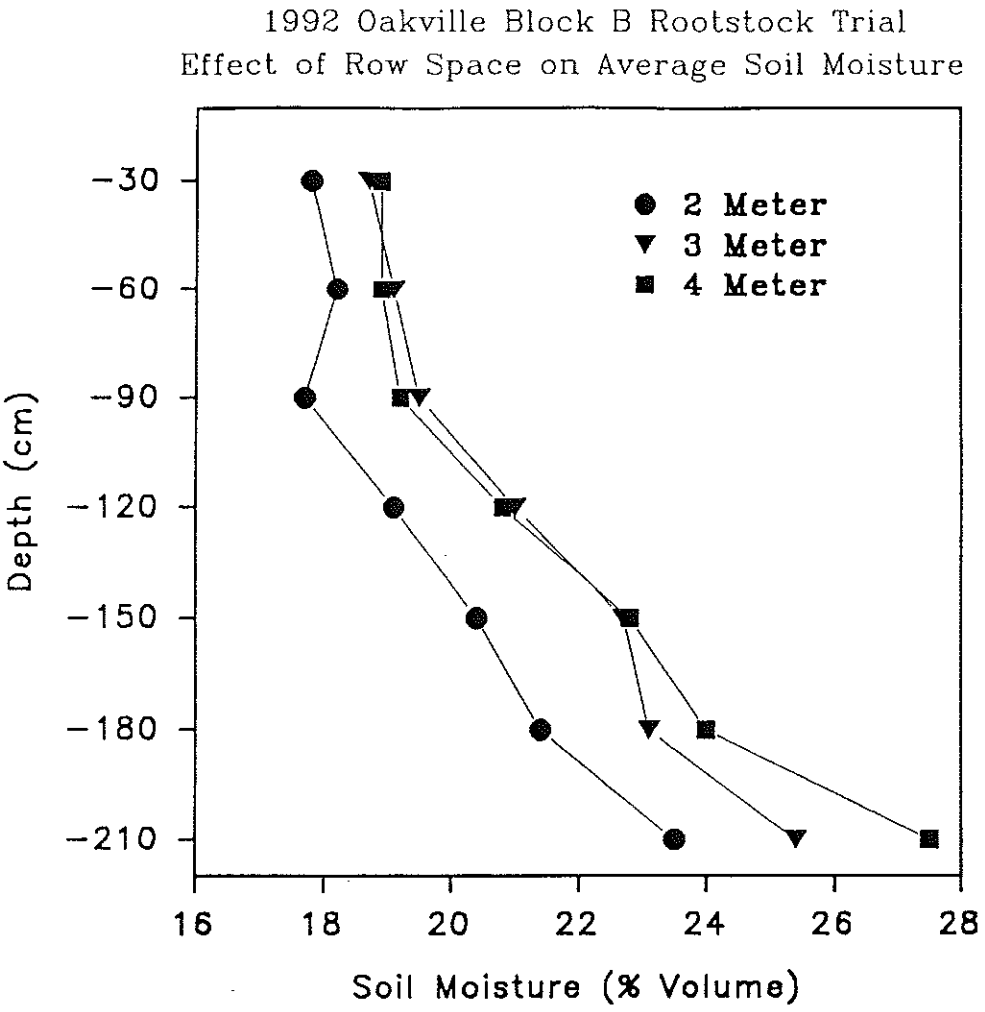
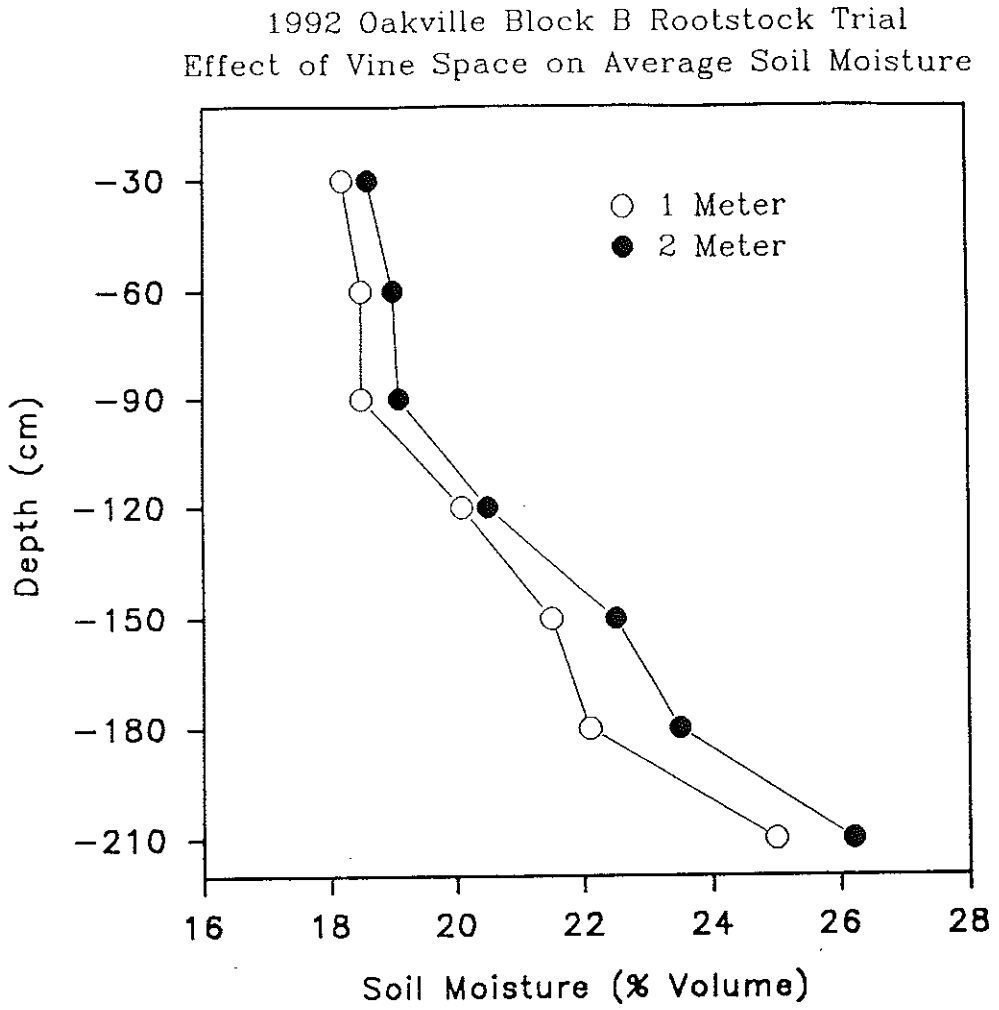


FIGURE 3 INFLUENCE OF VINE SPACING ON THE AMOUNT OF SOIL MOISTURE AT DIFFERENT DEPTHS. DATA IS FOR THE 1992 SEASON. FOR EACH VINE SPACING THE DATA FROM SEVEN ROOTSTOCKS HAS BEEN COMPOSITED TOGETHER.



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LW

Richard S. Supat
Program Supervisor
Department of Food and Agriculture
Division of Inspection Services
1220 N. Street
Sacramento, California 95814

Dear Dick,

Enclosed is a copy of the progress report for research on **Determination of Rot and Mold Levels in Harvested Wine Grapes.** This report was prepared for the Wine Growers Association and was sent to Mr. Robert D. Reynolds, the executive director, on 9 November 1987.

Please feel free to contact Jim or me if you would like further information on past or ongoing research. We will be contacting you soon to discuss future possibilities of CDFA support for our research.

Yours truly,

Rob

Robert W. Ricker