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Grape Cultivar Performance in the Missouri Ozark Region

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Abstract

Two grape cultivar trials were established at Southwest Missouri State University, State Fruit Experiment Station starting in 1985. Twenty-seven wine and ten table grape cultivars were planted in a Viraton silt loam, a shallow soil typical for the Ozark region. Based on overall productivity (yield, pruning weight, juice composition) over four or more years the wine cultivars best suited for the region were 'Catawba,' 'Cayuga White,' 'Chambourcin,' 'Norton,' 'Seyval blanc,' 'Vidal blanc,' and 'Vignoles.' The best table cultivars were 'Mars' and 'Reliance.'

Introduction

Missouri grape production has a long history dating back to the mid 1800's (1,7,13). Breeding work was conducted in southern Missouri at the State Fruit Experiment Station in Mountain Grove from 1899 until 1984. Twelve grape cultivars were released in the mid-1940's from crosses of native *Vitis* species and *Vitis vinifera* (15). Few are commercially planted today. 'Challenger' was released in 1983 as a table grape (6).

In 1980 the Missouri grape industry included American species and their hybrids, and French hybrids (3, 11). The primary cultivars planted included 'Catawba,' 'Concord,' 'Niagara,' and 'Virginia Seedling' of the American species and 'Baco noir,' 'Chancellor,' 'Chelois,' and 'Villard blanc' of the French-American hybrids. There were 1,500 bearing acres reported in that year and the expected trend was toward an increase in acreage (11).

An initial report on grape research at Mountain Grove in 1980 listed 'Cayuga White,' 'Chelois,' 'Rougeon,' 'Seyval blanc,' 'Vidal blanc,' and 'Villard blanc' as high yielding (9). These cultivars had moderate pruning weights up to one kg per vine and lower disease ratings than the other cultivars under test.

By 1987 grapes were planted on 1,459 acres of which 542 acres were of 'Concord' (12). Those producers who were members of the National Grape Cooperative Association had a ready market for their fruit until contracts were canceled after the 1991 season.

A 1999 survey showed a decline in grape acreage with most of the loss in 'Concord' (5). Presently, growth is occurring in the Missouri grape industry. Cultivars being planted include 'Catawba,' 'Cayuga White,' 'Chambourcin,' 'Chardonel,' 'Cynthiana,' 'Norton,' 'Seyval blanc,' 'St. Vincent,' 'Vidal blanc,' 'Vignoles,' and 'Vivant' (5). There is a demand by wineries in Missouri for most of these cultivars but labor unavailability is a major impediment to vineyard expansion. A few *Vitis vinifera* cultivars are planted on very small acreage where winter protection can be implemented.

The objective of this trial was to determine the productivity of grape cultivars in Missouri. Several grape cultivars that are being grown commercially were included for comparison. Cultivar evaluation was carried out on a shallow soil typical for the Ozark region.

Materials and Methods

Two grape cultivar trials were established at the Southwest Missouri State University, State Fruit Experiment Station at Mountain Grove starting in 1985. This location is in plant hardiness zone 6A. Average maximum and minimum temperatures at Mountain Grove were 30.4 and –4.4 °C, respectively (1961-1990); extreme high and low temperatures were 43.3 and –29.4 °C, respectively (1901-1996) (10). Average annual precipitation at

Mountain Grove is 1110 mm (1961-1990) (10). Twenty-seven wine grape cultivars in one vineyard and ten table grape cultivars in a second vineyard were planted over a four-year period (Table 1).

Vines were grown in a Viraton soil type, consisting of silt loam topsoil overlying a cherty, silty, clay loam subsoil (14). Topsoil had a pH of 6.0 and organic matter content of 2.3%. A fragipan occurred in the subsoil at a 50 cm depth. Experimental design for both vineyards was a randomized complete block with five replications. Each replicate consisted of twelve vines for wine grape cultivars and eighteen vines for table grape cultivars. Vine spacing was 2.4 m within rows and 3.0 m between rows. Vine training was to a bilateral, single curtain, cordon system with five node canes. Balance pruning was used to adjust node number (8). Most cultivars were pruned to 30 nodes for the first 0.45 kg of canes removed plus 10 nodes for each additional 0.45 kg of canes removed with a maximum of 60 nodes retained. Previous experience with some French-American hybrid and table grape cultivars showed them to be less vigorous. These were pruned to retain 20 nodes for the first 0.45 kg of canes removed.

Cluster thinning at one to two clusters per shoot was used to regulate crop on large clustered cultivars in high crop years. Pesticides were applied according to Missouri recommendations (16). Kentucky bluegrass (*Poa pratensis* L.) sod was established in the row middles and mowed during the growing season. Pre and postemergent herbicides were applied to control weeds along a one meter wide strip under the trellis. Drip irrigation was used to supplement rainfall during extended dry periods. Nitrogen was applied yearly at 75 $kg \cdot ha^{-1}$. Soil and foliar samples were taken periodically to determine the nutritional status of the vineyard.

Yield, pruning weight, cluster weight, and juice soluble solids concentration (SSC), titratable acidity (TA) and pH were recorded for four or more years starting in the fourth year (Tables 2, 3, 4, 5, 6, 7). A laboratory refractometer and pH meter were used to measure SSC and pH, respectively. The procedure by Dharmadhikari and Wilker was used to measure TA (4). Data were subjected to analysis of variance with least significant difference reported ($P = 0.05$).

Results and Discussion

The cultivars in this study included a number of American species and their hybrids, French-American hybrids, and more recent releases from breeding programs in the United States and Canada (Table 1). All but two, 'Festivee' and 'Vinered,' of the table grape cultivars were seedless.

On a yield per vine basis, the highest yielding wine cultivars were 'Catawba,' 'Cayuga White,' 'Chelois,' 'Delaware,' 'LaCrosse,' 'Missouri Riesling,' 'Seyval blanc,' 'Vidal blanc,' and 'Villard noir' (Table 2). These could exceed ten kg per vine in a good production year. Lowest yielding cultivars were 'Bellandais' and 'Vignoles.' These yielded six kg or less per vine. The remaining wine cultivars were intermediate in yield, usually between six and ten kg per vine. Two consecutive days of morning frost (–0.6 °C) occurred on May 6 and 7 in 1992 which greatly reduced yield that year.

Yield has not been a deciding factor in cultivar acceptance by the Missouri wine industry. For example 'Norton' and 'Vignoles' had intermediate and low yields, respectively, but are widely grown because of their excellent wine quality (17). In contrast 'LaCrosse,' 'Missouri Riesling,' and 'Villard noir' had higher yields, but are not well accepted by the Missouri wine industry (17). Several cultivars combine higher yields with a good balance in SSC, TA, and pH for wine, namely 'Catawba,' 'Cayuga White,' 'Seyval blanc,' and 'Vidal blanc.' These have become widely planted in Missouri. The cultivar 'Chambourcin' which was intermediate in yield has also been planted.

Highest yielding table cultivars were 'Reliance' and 'Vinered' (Table 2). These could yield ten or more kg per vine in a good production year. Lowest yielding table cultivars were 'Challenger,' 'Einset,'

Table 1. Grape cultivars at Mountain Grove, MO., origin and year of planting.

Cultivar	Origin	Year of planting
Wine Grapes		
Aurore	French-American hybrid	1985
Baco noir	French-American hybrid	1985
Bellandais	French-American hybrid	1988
Catawba	American hybrid	1985
Cayuga White	New York	1985
Chambourcin	French-American hybrid	1986
Chancellor	French-American hybrid	1985
Chelois	French-American hybrid	1985
Couderc noir	French-American hybrid	1988
DeChaunac	French-American hybrid	1985
Delaware	American hybrid	1985
Horizon	New York	1988
LaCrosse	Minnesota	1988
Leon Millot	French-American hybrid	1985
Marechal Foch	French-American hybrid	1985
Melody	New York	1987
Missouri Riesling	Missouri	1985
Niagara	American hybrid	1988
Norton	Vitis aestivalis	1985
Rayon d'Or	French-American hybrid	1987
Rougeon	French-American hybrid	1986
Seyval blanc	French-American hybrid	1985
Ventura	Ontario, Canada	1988
Vidal blanc	French-American hybrid	1985
Vignoles	French-American hybrid	1985
Villard noir	French-American hybrid	1985
Vivant	Ontario, Canada	1988
Table Grapes		
Canadice	New York	1986
Challenger	Missouri	1986
Einset	New York	1987
Festivee	Ontario, Canada	1985
Himrod	New York	1985
Mars	Arkansas	1985
Reliance	Arkansas	1985
Vanessa	Ontario, Canada	1985
Venus	Arkansas	1985
Vinered	Ontario, Canada	1985

Table 2. Grape cultivar yield (kg) at Mountain Grove, MO.

Cultivar	Yield (kg/vine)						Average
	1989	1990	1991	1992	1993	1994	
Wine Grapes							
Aurore	7.4	6.5	8.4	3.4	10.8		7.3
Baco noir	5.7	5.1	9.6	1.4	5.9		5.5
Bellandais			5.1	1.1	3.9	3.0	3.3
Catawba	4.6	6.9	16.2	1.7	10.4		8.0
Cayuga White	12.6	5.8	17.3	5.7	19.8		12.2
Chambourcin	5.6	5.5	9.6	4.4	8.9		6.8
Chancellor	5.7	9.5	5.2	2.1	6.9		5.9
Chelois	6.3	9.4	13.7	2.9	10.5		8.6
Couderc noir			3.0	3.4	8.9	10.4	6.4
DeChaunac	10.0	7.5	7.7	1.6	6.9		6.7
Delaware	3.9	5.4	12.0	2.0	11.0		6.9
Horizon			7.8	1.5	2.5	8.1	5.0
LaCrosse			9.3	2.0	14.3	14.7	10.1
Leon Millot	4.6	7.1	7.6	1.5	5.7		5.3
Marechal Foch		5.9	8.8	1.5	8.8	5.3	6.1
Melody		5.2	9.9	2.6	9.8	7.8	7.1
Missouri Riesling	6.4	8.0	10.8	2.6	13.3		8.2
Niagara			7.9		8.7	8.2	8.3
Norton	3.9	4.6	9.4	1.9	9.1	9.9	6.5
Rayon d'Or		3.5	6.7	2.1	10.9	9.6	6.6
Rougeon	6.2	10.0	10.5	2.4	8.4		7.5
Seyval blanc	10.3	10.6	11.4	6.4	15.1	15.0	11.5
Ventura			7.2	1.2	10.2	10.6	7.3
Vidal blanc	7.7	5.9	15.9	4.4	13.0		9.4
Vignoles	3.4	6.0	4.9	2.0	5.3	4.1	4.3
Villard noir	10.9	10.2	8.4	5.8	10.8		9.2
Vivant		3.2	4.9	3.3	5.8	10.2	5.5
LSD ($P = 0.05$)	1.7	0.6	1.9	1.3	2.3	1.8	
Table Grapes							
Canadice		1.2	4.7	1.3	5.1	8.7	4.2
Challenger	5.9	0.4	3.3	0.2	2.9	2.7	2.6
Einset		0.3	3.8	0.5	2.8	4.0	2.3
Festivee	5.2	0.3	2.2	0.3	1.7	4.9	2.4
Himrod	3.8	2.8	4.8	0.2	0.6	1.9	2.4
Mars	7.9	2.6	7.7	0.7	4.0	7.3	5.0
Reliance	8.6	3.3	11.0	1.2	6.3	10.8	6.9
Vanessa	4.0	0.3	7.2	0.7	4.4	7.8	4.1
Venus	5.5	0.3	8.5	0.2	5.7	9.1	4.9
Vinered	9.2	0.4	13.1	1.5	14.0	12.1	8.4
LSD ($P = 0.05$)	2.0	0.6	1.6	0.7	1.6	2.6	

Table 3. Grape cultivar pruning weight (kg) at Mountain Grove, MO.

Cultivar	Pruning weight (kg/vine)						Average
	1988	1989	1990	1991	1992	1993	
Wine Grapes							
Aurore	0.8	0.8	0.9	0.8	0.5		0.8
Baco noir	3.1	2.0	1.6	1.4	2.1		2.0
Bellandais			0.3	0.6	0.9	1.0	0.7
Catawba	1.3	2.0	1.0	1.2	1.9		1.5
Cayuga White	1.8	1.2	1.1	1.0	0.9		1.2
Chambourcin	1.1	1.0	0.7	0.6	1.0		0.9
Chancellor	1.2	1.4	1.0	1.1	1.0		1.1
Chelois	2.0	4.3	1.8	1.9	2.6		2.5
Couderc noir			0.3	0.6	0.5	0.6	0.5
DeChaunac	2.5	2.5	1.9	1.7	2.4		2.2
Delaware	0.5	1.5	0.8	0.8	0.8		0.9
Horizon		1.3	1.1	1.3	0.7	1.1	1.1
LaCrosse		1.4	1.1	0.9	2.1	1.2	1.3
Leon Millot	1.1	1.5	1.0	1.0	1.6		1.2
Marechal Foch		1.7	1.0	0.8	1.1	0.9	1.1
Melody		1.7	1.1	0.9	1.1	1.0	1.2
Missouri Riesling	0.8	1.5	1.1	1.3	2.5		1.4
Niagara		1.2	0.5	0.7	1.5	0.9	1.0
Norton	1.3	1.5	1.0	1.0	1.8	1.6	1.4
Rayon d'Or		1.0	0.8	0.8	1.5	0.8	1.0
Rougeon	1.0	1.4	1.2	1.1	1.2		1.2
Seyval blanc	1.0	1.4	1.0	1.0	1.2	0.7	1.1
Ventura		0.7	1.1	1.2	2.1	1.0	1.2
Vidal blanc	1.3	1.4	1.1	1.0	1.1		1.2
Vignoles	0.8	0.8	0.6	0.7	0.8	0.7	0.7
Villard noir	1.4	1.5	1.0	1.3	1.6		1.4
Vivant		0.8	0.4	0.6	0.5	0.6	0.6
LSD ($P = 0.05$)		0.2	0.3	0.3	0.2	0.1	
Table Grapes							
Canadice		0.5	0.4	0.5	0.5	0.7	0.5
Challenger	1.5	1.5	0.9	1.3	1.1	1.3	1.3
Einset		0.4	0.7	0.6	0.8	0.9	0.7
Festivee	0.7	0.7	0.7	0.8	0.5	0.6	0.7
Himrod	0.6	0.9	0.6	0.8	0.6	0.9	0.7
Mars	1.4	1.6	1.3	1.8	1.8	1.9	1.6
Reliance	1.0	1.1	0.7	0.9	1.1	1.0	1.0
Vanessa	1.3	1.5	1.2	1.6	2.0	2.0	1.6
Venus	0.9	1.5	1.0	1.4	0.9	0.9	1.1
Vinered	0.6	0.9	0.9	1.0	1.2	1.1	1.0
LSD ($P = 0.05$)		0.4	0.3	0.4	0.2	0.2	

Table 4. Grape cultivar cluster weight (g) at Mountain Grove, MO.

	Cluster weight (g)						
Cultivar	1989	1990	1991	1992	1993	1994	Average
Wine Grapes							
Aurore	118	159	168	100	100		129
Baco noir	91	82	64	73	91		80
Bellandais			232	104	168	218	181
Catawba	141	150	182	132	136		148
Cayuga White	254	300	304	182	304		269
Chambourcin	259	304	209	277	186		247
Chancellor	141	250	173	150	159		175
Chelois	173	195	145	114	154		156
Couderc noir			191	114	186	236	182
DeChaunac	254	168	118	127	127		159
Delaware	95	100	100	86	123		101
Horizon		154	173	109	127	168	146
LaCrosse		100	154	95	109	154	122
Leon Millot	82	91	86	77	77		83
Marechal Foch		82	114	64	123	95	96
Melody		236	218	150	177	209	198
Missouri Riesling	114	82	114	109	91		102
Niagara		204	213		245	222	221
Norton	86	91	109	77	95	127	98
Rayon d'Or		182	204	163	191	218	192
Rougeon	150	204	127	82	132		139
Seyval blanc	259	372	363	222	263	322	300
Ventura		154	123	86	109	127	120
Vidal blanc	291	263	300	241	250		269
Vignoles	114	118	145	100	123	118	120
Villard noir	259	277	204	213	204		231
Vivant		118	127	136	150	186	143
LSD ($P = 0.05$)	34	31	18	25	18	41	
Table Grapes							
Canadice			215	112	173	168	167
Challenger	230		156	41	161	181	154
Einset			195	112	260	212	195
Festivee	269		196	52	159	222	180
Himrod	200	210	242	54	99	171	163
Mars	192	143	192	44	140	144	143
Reliance	288	254	297	127	158	202	221
Vanessa	143		207	77	140	164	146
Venus	259		272	69	146	171	183
Vinered	434		460	262	304	331	358
LSD ($P = 0.05$)	49	47	41	32	51	55	

'Festivee,' and 'Himrod.' 'Canadice,' 'Mars,' 'Vanessa,' and 'Venus' were intermediate in yield. The Missouri table grape industry is very small. 'Mars' and 'Reliance' have been the two seedless cultivars planted. 'Mars' has the familiar blue/black color and flavor that consumers associate with American grape species. The flavor of 'Reliance' is very good, but it does not color well in high temperature that regularly occurs during its normal ripening period in August.

Pruning weights are generally low to moderate at Mountain Grove. This location is typical for the Ozark region where shallow soil restricts vine growth. Weights between one and two kg per vine are desirable to sustain vine growth in this area. Wine grape pruning weights varied widely depending on cultivar and year (Table 3). 'Aurore,' 'Bellandais,' 'Chambourcin,' 'Couderc noir,' 'Delaware,' 'Rayon d'Or,' 'Vignoles' and 'Vivant' were generally one kg or less per vine. These cultivars probably need a better growing site with more soil depth to improve vigor. Weights above two kg per vine result in very dense canopies with single curtain, cordon training. In some years 'Baco noir,' 'Chelois' and 'DeChaunac' had these weights. Geneva double curtain (GDC) training may be needed for these cultivars. The remaining wine cultivars were intermediate with pruning weights between one and two kg per vine.

Table grape pruning weights were below one kg per vine for 'Canadice,' 'Einset,' 'Festivee,' and 'Himrod' (Table 3). The remaining cultivar pruning weights were usually one kg or higher. 'Reliance' and 'Mars' had pruning weights around one and two kg per vine, respectively.

Wine cultivars with smaller clusters of 120 g or less were 'Baco noir,' 'Delaware,' 'Leon Millot,' 'Marechal Foch,' 'Missouri Riesling,' 'Norton,' 'Ventura,' and 'Vignoles' (Table 4). Those with larger clusters of 200 g or more were 'Cayuga White,' 'Chambourcin,' 'Niagara,' 'Seyval blanc,' 'Vidal blanc,' and 'Villard noir.' Several of these cultivars required crop thinning to balance fruit production and vine growth in high crop years. The remaining wine cultivar cluster weights were intermediate from 120 to 200 g. Usually the small or medium cluster weight cultivars did not require crop thinning.

Table cultivars generally had medium size clusters between 150 and 200 g (Table 4). The largest clusters were of 'Reliance' and 'Vinered' which often exceeded 200 g. Larger clusters are desirable for fresh use because of their visual appeal. However, some cultivars required crop thinning in high production years.

For wine cultivars, a SSC of 20 to 24 °Brix will yield after fermentation an acceptable alcohol level for table wine (2). A titratable acidity (TA) of 0.65 to 0.80 g per 100 ml is also needed for a good table wine depending on the color and style (2). A juice pH of 3.4 or below at these SSC and TA levels is desirable to obtain microbial stability in wine (2,4). Wine cultivars that mature fruit close to these desired juice composition levels are preferred. In some Missouri growing seasons this juice composition can be difficult to obtain (17). Usually pH will rise well above 3.4 before a high enough SSC or a low enough TA is obtained. Table cultivars have a less stringent need for a balanced juice composition. Juice SSC should be sufficiently high and TA low enough for a sweet taste with some tartness. A SSC to TA ratio is often used to determine harvest (2).

Most wine cultivars had acceptable juice composition for wine (Tables 5, 6, 7). The best were 'Catawba,' 'Cayuga White,' 'Chambourcin,' 'Chancellor,' 'Delaware,' 'Marechal Foch,' 'Melody,' 'Norton,' 'Seyval blanc,' 'Ventura,' 'Vidal blanc,' 'Vignoles,' 'Villard noir,' and 'Vivant.' Even these cultivars sometimes had an imbalance in juice composition. Juice pH often rose above 3.4 before SSC was high enough ('Chancellor,' 'Delaware,' 'Marechal Foch,' 'Norton,' 'Seyval blanc') or TA low enough ('Chambourcin,' 'Marechal Foch,' 'Norton,' 'Vignoles'). Wine quality of 'Cayuga White' was generally best when harvested at a lower SSC and ameliorated (17).

Table 5. Grape cultivar soluble solids concentration (°Brix) at Mountain Grove, MO.

Cultivar	Soluble solids concentration (°Brix)						Average
	1989	1990	1991	1992	1993	1994	
Wine Grapes							
Aurore	20.1	23.0	20.2	14.6	16.9		19.0
Baco noir	18.3	21.6	20.9	17.3	18.0		19.2
Bellandais			21.9	20.9	18.8	18.2	20.0
Catawba	18.0	18.6	18.3	16.9	16.6		17.7
Cayuga White	17.5	19.4	16.4	17.5	14.9		17.1
Chambourcin	21.1	20.7	19.0	17.9	19.9		19.7
Chancellor	20.4	20.9	20.3	18.1	18.7		19.7
Chelois	20.4	21.5	21.1	17.8	21.0		20.4
Couderc noir			22.5	18.0	19.5	18.9	19.7
DeChaunac	19.9	22.8	20.4	17.6	18.7		19.9
Delaware	22.2	24.9	21.5	20.8	20.4		22.0
Horizon			18.5	14.0	17.3	16.5	16.6
LaCrosse			19.9	15.7	16.8	15.8	17.1
Leon Millot	20.7	21.4	22.7	19.8	19.7		20.9
Marechal Foch		22.7	23.0	17.5	20.1	21.7	21.0
Melody		21.5	17.7	17.0	18.0	16.4	18.1
Missouri Riesling	16.7	19.6	17.5	13.5	13.3		16.1
Niagara			17.8		15.5	13.7	15.7
Norton	22.7	21.1	20.8	22.0	21.7	22.8	21.9
Rayon d'Or		22.5	19.4	18.5	17.1	18.4	19.2
Rougeon	17.7	19.6	19.8	15.9	16.9		18.0
Seyval blanc	19.6	25.0	20.7	17.1	18.7	17.6	19.8
Ventura			22.1	19.1	17.3	17.8	19.1
Vidal blanc	20.2	20.8	19.0	15.1	16.0		18.2
Vignoles	23.2	22.6	25.0	19.5	22.1	22.0	22.4
Villard noir	19.6	18.8	20.9	18.1	19.3		19.3
Vivant		26.1	24.1	17.6	23.2	19.3	22.1
LSD ($P = 0.05$)	1.3	0.9	1.0	1.4	1.1	1.5	
Table Grapes							
Canadice			19.2	15.7	18.8	19.1	18.2
Challenger	18.3		18.8	15.9	19.6	19.7	18.5
Einset			17.5	16.8	18.2	18.7	17.8
Festivee	19.4		19.1	16.5	18.7	16.5	18.0
Himrod	18.7	20.8	20.9	17.2	19.0	20.8	19.6
Mars	17.9	17.8	17.1	13.0	16.2	15.4	16.2
Reliance	18.9	21.0	19.9	18.7	19.5	18.9	19.5
Vanessa	18.5		17.4	17.4	17.8	18.2	17.9
Venus	14.3		15.1	15.2	15.1	15.7	15.1
Vinered	18.8		18.3	19.4	16.1	16.5	17.8
LSD ($P = 0.05$)	0.7	0.7	1.1	1.3	1.0	1.2	

Table 6. Grape cultivar titratable acidity (g/ml) at Mountain Grove, MO.

Cultivar	Titratable acidity (g/ml)						
	1989	1990	1991	1992	1993	1994	Average
Wine Grapes							
Aurore	0.81	0.62	0.63	1.51	0.79		0.87
Baco noir	0.91	1.14	0.98	1.48	0.87		1.08
Bellandais			0.52	0.98	0.61	0.94	0.76
Catawba	0.90	0.82	0.81	1.43	0.77		0.95
Cayuga White	0.55	0.72	0.69	0.98	0.75		0.74
Chambourcin	0.94	0.95	0.84	1.29	0.74		0.95
Chancellor	0.53	0.74	0.83	1.22	0.66		0.80
Chelois	0.92	0.73	0.70	1.53	0.65		0.91
Couderc noir			0.71	0.82	0.69	0.79	0.75
DeChaunac	0.71	0.77	0.61	1.31	0.73		0.83
Delaware	0.53	0.74	0.66	0.97	0.47		0.67
Horizon			0.68	1.02	0.75	0.71	0.79
LaCrosse			0.69	1.39	0.91	0.77	0.94
Leon Millot	0.51	0.79	0.72	0.99	0.81		0.76
Marechal Foch		0.99	0.89	1.21	0.94	0.99	1.00
Melody		0.76	0.73	1.12	0.61	0.97	0.84
Missouri Riesling	0.81	0.78	0.76	1.45	0.98		0.96
Niagara			0.38		0.41	0.57	0.45
Norton	1.13	0.97	0.90	1.38	1.13	1.26	1.13
Rayon d'Or		0.58	0.97	1.23	0.62	1.03	0.89
Rougeon	0.64	0.54	0.59	1.17	0.59		0.71
Seyval blanc	0.65	0.64	0.76	0.99	0.64	0.79	0.75
Ventura			0.62	1.57	0.82	1.19	1.05
Vidal blanc	0.82	0.79	0.75	1.42	0.64		0.88
Vignoles	0.81	1.06	0.76	1.46	0.94	1.23	1.04
Villard noir	0.77	0.76	0.82	1.17	0.74		0.85
Vivant		0.73	0.72	1.23	1.03	0.91	0.92
LSD ($P = 0.05$)	0.11	0.07	0.07	0.18	0.07	0.09	
Table Grapes							
Canadice			0.66	1.15	0.58	0.70	0.77
Challenger	0.71		0.57	1.48	0.53	0.61	0.78
Einset			0.73	0.83	0.70	0.79	0.76
Festivee	0.44		0.64	1.36	0.51	0.84	0.76
Himrod	0.63	0.61	0.59	1.04	0.60	0.61	0.68
Mars	0.44	0.51	0.57	1.11	0.62	0.88	0.69
Reliance	0.64	0.60	0.53	0.95	0.56	0.63	0.65
Vanessa	0.54		0.49	0.75	0.39	0.57	0.55
Venus	1.07		0.81	1.08	0.54	0.74	0.85
Vinered	0.64		0.57	0.94	0.68	1.00	0.77
LSD ($P = 0.05$)	0.06	0.05	0.07	0.29	0.02	0.08	

Table 7. Grape cultivar pH at Mountain Grove, MO.

Cultivar	pH						Average
	1989	1990	1991	1992	1993	1994	
Wine Grapes							
Aurore	3.48	3.53	3.53	3.07	3.37		3.40
Baco noir	3.55	3.24	3.55	3.38	3.38		3.42
Bellandais			3.76	3.43	3.42	3.35	3.49
Catawba	3.22	3.32	3.36	3.18	3.29		3.27
Cayuga White	3.34	3.34	3.47	3.26	3.20		3.32
Chambourcin	3.46	3.34	3.44	3.14	3.31		3.34
Chancellor	3.69	3.36	3.58	3.32	3.48		3.49
Chelois	3.50	3.45	3.64	3.28	3.53		3.48
Couderc noir			3.69	3.37	3.35	3.31	3.43
DeChaunac	3.64	3.51	3.71	3.14	3.50		3.50
Delaware	3.63	3.42	3.46	3.44	3.63		3.52
Horizon			3.50	3.59	3.33	3.44	3.47
LaCrosse			3.53	3.45	3.26	3.48	3.43
Leon Millot	3.82	3.45	3.84	3.45	3.56		3.62
Marechal Foch		3.46	3.69	3.50	3.49	3.53	3.53
Melody		3.38	3.42	3.47	3.37	3.31	3.39
Missouri Riesling	3.48	3.56	3.50	3.30	3.24		3.42
Niagara			3.74		3.59	3.30	3.54
Norton	3.46	3.41	3.66	3.42	3.43	3.48	3.48
Rayon d'Or		3.56	3.32	3.31	3.40	3.17	3.35
Rougeon	3.56	3.64	3.70	3.23	3.56		3.54
Seyval blanc	3.47	3.55	3.43	3.33	3.35	3.18	3.39
Ventura			3.47	3.06	3.17	3.20	3.23
Vidal blanc	3.37	3.33	3.37	3.22	3.15		3.29
Vignoles	3.25	3.13	3.51	3.23	3.26	3.20	3.26
Villard noir	3.43	3.30	3.51	3.29	3.40		3.39
Vivant		3.47	3.43	3.34	3.19	3.21	3.33
LSD ($P = 0.05$)	0.11	0.07	0.09	0.07	0.08	0.07	
Table Grapes							
Canadice			3.29	3.05	3.31	3.28	3.23
Challenger	3.25		3.34	3.02	3.45	3.46	3.30
Einset			3.13	3.20	3.09	3.18	3.15
Festivee	3.70		3.37	3.18	3.52	3.33	3.42
Himrod	3.23	3.18	3.23	3.00	3.21	3.30	3.19
Mars	3.40	3.32	3.38	2.93	3.31	3.33	3.28
Reliance	3.31	3.23	3.18	3.08	3.38	3.27	3.24
Vanessa	3.40		3.38	3.12	3.52	3.35	3.35
Venus	2.90		3.19	3.15	3.24	3.18	3.13
Vinered	3.31		3.54	3.32	3.29	3.28	3.35
LSD ($P = 0.05$)	0.06	0.05	0.09	0.11	0.06	0.07	

The table cultivars could be matured to a good balance in SSC and TA for fresh fruit consumption (Tables 5, 6, 7). 'Mars' and 'Venus' which are blue/black in color and early ripening were susceptible to bird feeding before SSC was high enough. These could be ripened longer to achieve a desirable balance when birds were excluded with netting.

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