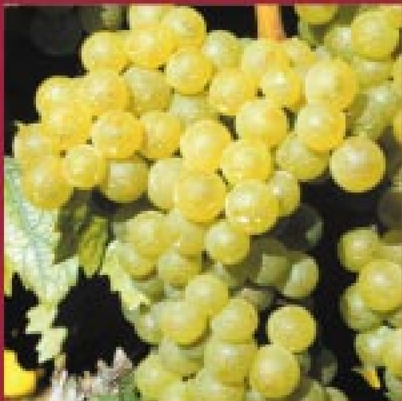

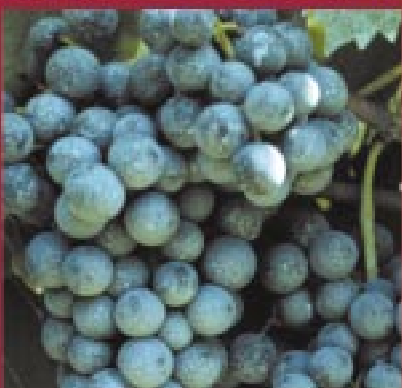

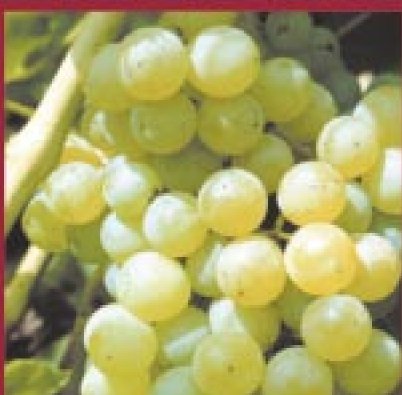

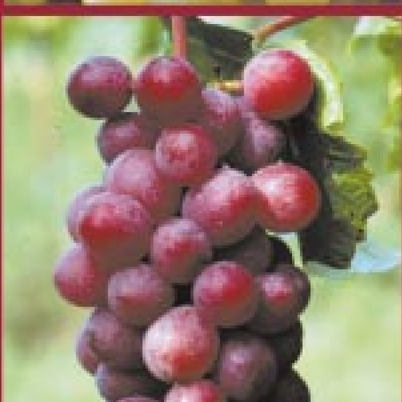

Commercial Grape Varieties for Virginia

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Virginia Tech
Virginia Polytechnic Institute and State University
Virginia State University

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Tony K. Wolf

Imed E. Dami

Bruce W. Zoecklein

M. Kay Warren*

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* Viticulture Extension Specialist, Viticulture Extension Assistant, Research Enologist, and Research Specialist, respectively; Virginia Tech

Contents

Introduction

Suitability of grape varieties

Grape varieties recommended in this publication have demonstrated commercial suitability under diverse growing conditions in Virginia. Strengths and weaknesses of each variety are based on the collective experiences of numerous commercial growers and vintners and, for some varieties, from controlled comparisons in research plots. A variety recommended as "suitable" does not guarantee that the variety will flourish and consistently produce high yields of quality fruit for all growers. Rather, "suitable" is a relative term. A good grower at a good site will have a greater probability of success with a suitable variety than with an unsuitable variety. Suitability is also based on positive winery demand for the variety.

The current varietal composition of Virginia viticulture is depicted in Figure 1. Note that 72% of the acreage is represented by only seven varieties, and the remaining 28% of acreage is comprised of over 20 other varieties.

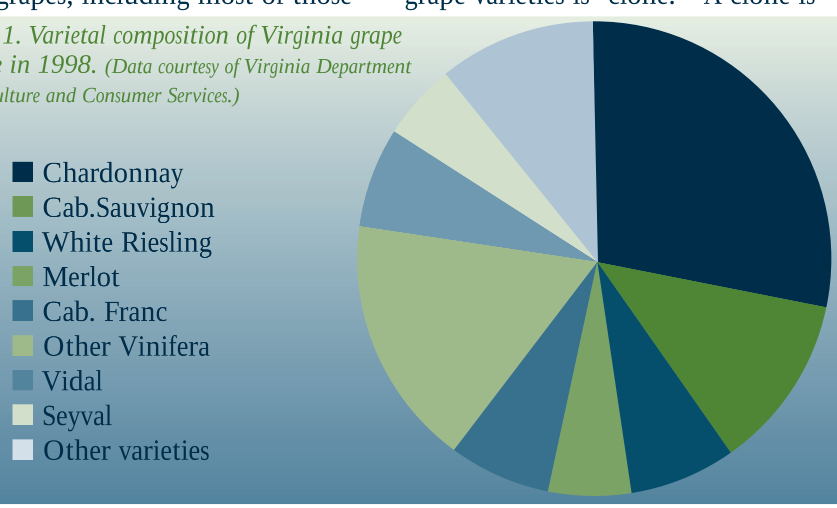
Species, cultivars, varieties and clones

Grapevines are members of the genus Vitis, which includes two subgenera, *Euvitis and Muscadinia*. Euvitis (true grapes) includes over 60 species of bunch grapes, including most of those found in Virginia. Muscadinia is comprised of only three species, including *Vitis rotundifolia*.

There are few places in the world that can claim the diversity of grape species indigenous to and cultivated in Virginia. Indigenous *Euvitis* species include *V. aestivalis, V. cinerea, V. labrusca, V. riparia, V. rupestris, and V. vulpina* (Massey, 1945). Most of these native species are ill-suited to quality wine production, but some provide important genetic sources of pest resistance in rootstock and scion (Fruiting portion of vine) breeding programs. The majority (>70%) of commercial grape production is based on members of another species, *V. vinifera*. *Vitis vinifera* grapes, sometimes called European grapes, dominate world wine production. Virginia wines are also made from (*V. aestivalis)* (e.g., Norton), and *V. labrusca* (e.g., Niagara). Additionally, interspecific hybrid grapes (e.g., Vidal) constitute at least 20% of Virginia grape acreage. Members of the sub-genera, *Vitis rotundifolia*, the muscadine grapes (e.g., Scuppernong), are cultivated in the southeastern portion of the state. Muscadines are typically used only for fresh consumption in Virginia.

A named, cultivated variety is formally referred to as a "cultivar." However, the more common designation of "variety" is used in this bulletin because of its greater use in non-technical publications. Another term that is increasingly used in discussions of wine grape varieties is "clone." A clone is more specific than a variety. A clone refers to one or more vines that originated from an individual vine, which was in some way unique from other vines of that variety. The unique vine can be vegetatively propagated by taking cuttings. Each plant derived from such cuttings is a clone of the parent plant, and the group of plants can be collectively given a clonal name, such as Chardonnay FPMS (Foundation Plant Materials Service) clone #4. A new clone can arise when someone selects a particular vine that might stand out from other vines of that variety on the basis of greater yields or better fruit quality. The factors that can contribute to clonal variation are numerous but have frequently involved genetic mutations or virus infections. Although more attention is being given to selecting certain clones for specific planting locations, research with different clones in Virginia is limited. More specific information on viticultural and enological characteristics of some common clones is available from the Foundation Plant Materials Service of the University of California at Davis, California, and in the Proceedings of the ASEV Clonal Symposium of 1995 (see References).

Figure 1. Varietal composition of Virginia grape acreage in 1998. (Data courtesy of Virginia Department of Agriculture and Consumer Services.)



Pollination

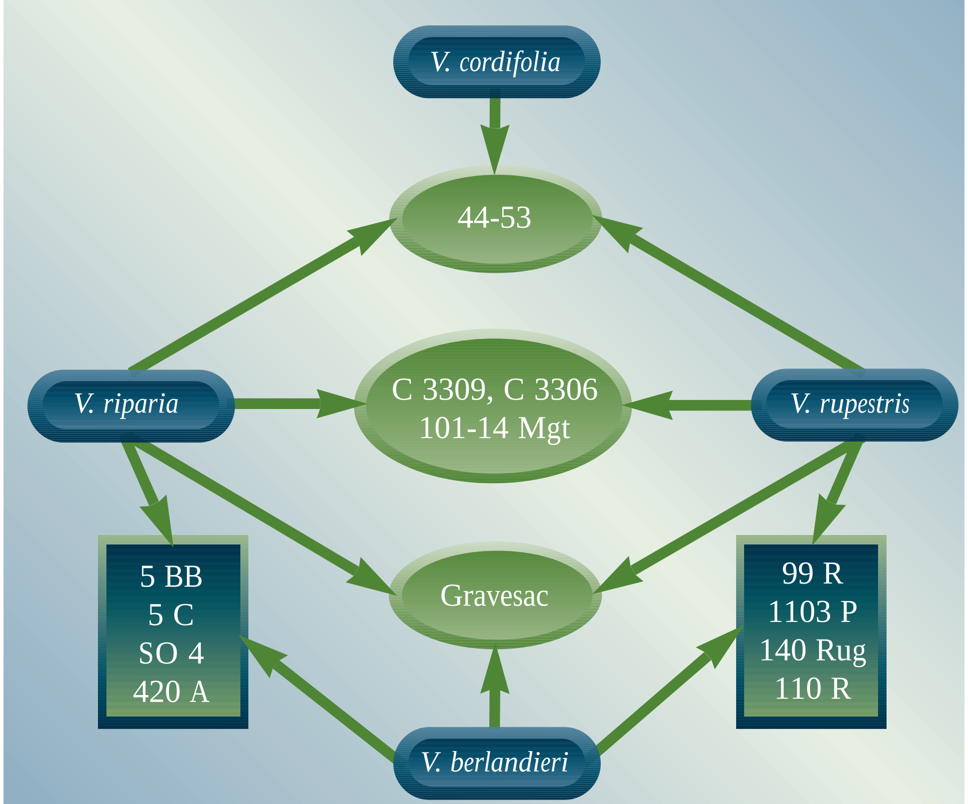
All of the commonly planted fruiting grapevines in Virginia are self-pollinated, and therefore self-fruitful; they can therefore be planted in large contiguous blocks without the need for cross-pollinating varieties. Some muscadine grape varieties (*V. rotundifolia*) do, however, require a pollinator. Growers interested in muscadine grapes should determine in advance if a pollinator is necessary (Poling *et al.*, 1985).

Rootstocks

All vinifera grapes grown in Virginia should be grafted to a pest resistant rootstock. Grafting is the process of joining a rootstock with the scion variety to form a single plant. The primary reason for grafting is to provide tolerance of the phylloxera root louse. Phylloxera are small aphid-like insects which feed on roots, weakening and killing the vine. Phylloxera are indigenous to eastern North America. Aerial forms of the insect also cause galling on foliage, and in some cases must be controlled with insecticides to avoid economic damage to the vine. Rootstocks can also be used with hybrids and American varieties to increase scion vigor. The scion is the above-ground, fruiting portion of a grafted vine. Grafting of non-vinifera vines might be desirable for soils that are inherently low in nutrients or water-holding capacity and where experience has demonstrated low vine vigor. Grafting is specifically recommended for several of the hybrid varieties in Virginia to impart resistance to nematode-transmitted viruses, or to provide phylloxera tolerance to hybrids that have a large vinifera component in their parentage.

The parentage of major rootstocks used in Virginia is illustrated in Figure 2. Almost all rootstocks derive from the combinations of three species: *V. riparia*, *V. rupestris*, and *V. berlandieri*. The following description of rootstocks is based on research results, grower experience, or both, under a wide range of growing conditions. All the rootstocks described below have good to excellent tolerance of phylloxera, which should be the first criterion for the choice of a rootstock. In addition to the listed rootstocks, there are numerous others available, some of which have been developed for special soil conditions or to provide resistance to specific soil pests. Rootstock selection should be based on physical and chemical properties of the soil, its water-holding capacity, scion variety growth characteristics, as well as the intended vine spacing, training system, and other cultural inputs (Delas, 1992). Although rootstock trials have not been conducted in Virginia, we recommend the use of rootstocks with excellent phylloxera resistance, that induce moderate to low vigor, and that minimize nutritional problems (Table 1).

Figure 2. Schematic diagram of the parentage of principal rootstocks used for wine grapes.



Vitis riparia x *V. rupestris* (C-3309, C-3306, 101-14, Schwarzmann): *Vitis riparia* offers excellent phylloxera resistance and good adaptation to moist soils. Rootstocks derived from *V. riparia* x *V. rupestris* crosses prefer fertile, deep, and moist soils. C-3309 is the most commonly used and generally recommended rootstock in Virginia, and is a member of this group. Scion vigor is low to moderate. Dry, shallow, and heavy soils are not as suitable for C-3309. Experiences in South Africa (Southey, 1992) indicate good resistance to crown gall. C-3309 is reportedly susceptible to nematodes (Delas, 1992), especially root-knot nematodes (Emmet *et al.*, 1992); however, this has not been examined in Virginia. C-3309 may induce potassium deficiency with over-cropped, young vines on clay soils (Delas, 1992). Another rootstock in this group is 101-14, which is considered less vigorous than C-3309. Situations in which 101-14 may be superior to C-3309 would include sites with deep, fertile soils, or with very vigorous scion varieties (e.g. Cabernet Sauvignon).

Vitis berlandieri x *V. riparia* (5 BB, 5 C, SO4, 420 A): *Vitis berlandieri* is indigenous to the alkaline soils of the southwest USA; thus it is well adapted to limestone soils and drought. Generally, rootstocks from this group are more vigorous than those from *V. riparia* x *V. rupestris* crosses, especially under readily available water from rainfall and/or irrigation. However, they are more drought tolerant than the *V. riparia* x *V. rupestris* rootstocks. In Virginia, 5C has been extensively used under the mistaken name of SO4. 5C is widely used in California, and is well suited to well-drained, fertile soils, and could be a good choice for heavy soils (clays and clay loams). 5C does not, however, perform well in dry soils. It has good resistance to root-knot and dagger nematodes. 5BB and SO4 are commonly available, but they tend to produce larger, more vigorous vines than is desirable for conventional plant spacings and training systems. SO4 does best in light, well drained soils of low fertility. Reports from France indicate that SO4 is susceptible to magnesium deficiency, and that the combination of Cabernet Sauvignon grafted to SO4 is particularly susceptible to late-season bunch stem necrosis (Delas, 1992). In New York State, vines grafted to SO4 or 5C produced greater crop yields than did C-3309 due to larger vine size; however, vines grafted to SO4 or 5C also sustained greater cold injury than did those grafted to C-3309 (Pool *et al.*, 1992).

Vitis rupestris x *V. berlandieri* (99 R, 110 R, 140 Ru, 1103 P): *Vitis rupestris* and *V. berlandieri* are well adapted to drought stress; thus rootstocks produced from them are suited to warm regions where water is limited. These rootstocks were developed for Mediterranean-like growing conditions and non-irrigated vineyards. This group has the most vigorous rootstocks and the best adaptability to poor growing conditions, including infertile soils and drought. These rootstocks are not commonly used in Virginia, but they may be worth considering in low-vigor sites with poor soils and no irrigation.

Other complex crosses: *Vitis riparia* x *V. cordifolia* x *V. rupestris* (44-53M): 44-53M has attributes similar to C-3309 and should be suitable for a wide range of conditions found in Virginia; however, we lack such experience. 44-53M has moderate vigor, performs well under dry conditions, and tolerates somewhat acidic soils.

V. riparia x *V. berlandieri* x *V. rupestris* (Gravesac): This is a relatively new rootstock (ca. 1985) developed in Bordeaux, France, for tolerance to acidic soils. Gravesac has moderate vigor and is suited for well drained soils of low fertility. Availability of Gravesac among North American nurseries is limited.

Table 1. Characteristics and performance of major rootstocks reported from various viticultural regions. Source: Howell (1987), Galet (1979), Kasamatis and Lider (1980), Pongracz (1983), Wolpert *et al.* (1992).

			Nematodes[z]		Crown	Scion		Soil	Soil	Water	Veg.
Rootstock	Vitis species parentage	Phyllx[z]	R-K	DG	gall[z]	vigor[y]	Drought[z]	alkal.[x]	acidity [z]	logging[z]	Maturity[w]
Gloire	Riparia	5	3	v	v	1	1	1	2	4	+
St. George	Rupestris	4	1	1	v	4	3	3	2	2	-
3309 C	Riparia x Rupestris	4	2	4	4	3	2	2	1	4	+
3306 C		4	3	1	v	3	1	2	2	v	+
101-14		4	3	2	4	2	1	2	1	4	+
5 BB	Berlandieri x Riparia	4	3	2	4	4	2	4	2	4	+
5 C		4	4	4	v	4	2	3	v	4	+
SO4		4	4	2	2	4	2	3	1	4	+
420 A		4	2	2	v	3	2	4	v	3	+
99 R	Rupestris x Berlandieri	4	4	v	1	4	3	3	3	2	-
110 R		4	3	2	1	3	5	4	3	3	-
140 Ru		4	2	v	1	5	5	5	4	3	-
1103 P		4	4	2	2	3	4	4	3	4	-
44-53 M	Riparia x Rupestris x cordifolia	4	2	3	v	3	2	2	2	4	+
Gravesac	Riparia x Berlandieri x Rupestris	5	2	v	v	3	3	3	3	v	v

z 1= sensitive (or susceptible); 5= resistant (or tolerant). Phyllx = Phylloxera; R-K = Rootknot nematode; DG = Dagger nematode
y 1=low vigor; 5= high vigor
x Tolerance to % lime, a measure of soil alkalinity: 1= sensitive to value below 10%; 5= tolerant to value above 30%
w Scion vegetative maturity in fall: "+" = advances maturity; "-" = delays maturity
v Data not available

Fungal disease resistance:

All commonly grown commercial grape varieties in Virginia are susceptible to one or more foliar and fruit diseases (Table 2). The most common diseases include black rot, powdery mildew, and downy mildew. Certain cultural practices reduce the severity of these fungal diseases, but economic control is only achieved with the use of a fungicide spray program. Grape pesticide recommendations are annually updated by Virginia Cooperative Extension and are available from Cooperative Extension offices.

Home grape production:

Some "commercial" grape varieties are suitable for home wine and table grape production and notes to this effect are made throughout the text. As a group, the vinifera varieties are not recommended for home production because of their greater disease susceptibility.

Grape markets and crop value:

Thoroughly explore the market for any grape variety before considering commercial production. Contact wineries before you commit to a particular variety, and determine what those wineries will be buying in the foreseeable future. Certain grape varieties are relatively easy to grow in Virginia but lack market appeal. On the other hand, a winery might express a strong interest in buying grapes that are difficult to consistently crop (e.g., Merlot and Sauvignon blanc). Therefore, unless you are confident that you have an excellent vineyard site, or you can financially tolerate the occasional bad years, plant varieties that have better track records. A model grower-vintner harvest contract is available upon request. Current crop values will also affect the choice of variety or varieties grown. Grape prices in Virginia have increased by about 3% per year over the past 10 years. *High quality* fruit of hybrid varieties such as Vidal and Chambourcin is currently valued at $600 to $750 per ton, while *high quality* vinifera crops average $1150 to $1400 per ton. Exceptions occur in both directions from these ranges; prices are reduced for inferior fruit quality, and prices of some exotic varieties (e.g., Viognier, Touriga nacionale) are currently greater than $1400 per ton.

Winery demand for grapes:

Many of Virginia's wineries purchase grapes from one or more independent grape producers to augment their own grape production. Wineries were surveyed in 1996 to determine which varieties were needed then and for the foreseeable future. Specifically, winery owners were asked how many tons of grapes they would purchase — if those grapes were available - in excess of their current supply. At that time, 14 wineries indicated that they wished to purchase additional tonnage from independent producers. The desired

Table 2. Relative disease susceptibility and sulfur phytotoxicity of major grape varieties in Virginia.

Variety	Black rot	Downy mildew	Powdery mildew	Botrytis bunch rot	Sulfur phytotoxicity[z]
Cabernet franc	+++	+++	+++	-	-
Cabernet Sauvignon	+++	+++	+++	-	-
Chambourcin	+	+	+++	-	+++
Chardonel	++	++	+	-	-
Chardonnay	+++	+++	+++	+++	-
Malvasia bianca	+++	+++	+++	?	-
Merlot	+++	+++	+++	+	-
Muscat Ottonel	+++	+++	+++	?	-
Norton	+	+	+	-	+++
Riesling	+++	+++	+++	++	-
Sauvignon blanc	+++	+++	+++	+++	-
Seyval	+++	++	++	+++	+
Tannat	+++	+++	+++	-	-
Vidal	++	++	+	-	+
Viognier	+++	+++	+++	+	-

Key to ratings:
+++ highly susceptible/sensitive, ++ moderately susceptible/sensitive, + slightly susceptible/sensitive, ? uncertain susceptibility/sensitivity, - not normally susceptible.
z Sulfur phytotoxicity refers to plant injury that can result from the application of sulfur fungicides.

Table 3. Annual grape tonnage that Virginia winery owners expressed an interest in purchasing from independent sources (data collected August 1996).

Variety	Tons/year
Chardonnay	266
Merlot	118
Riesling	94
Cabernet franc	69
Cabernet Sauvignon	62
Sauvignon blanc	17
Viognier	10
Pinot gris	10
Pinot noir	9
Vidal	198
Seyval	115
Chambourcin	30
Norton	5
Total	1003

tonnage, by variety, is shown in Table 3. The unfulfilled demand for grapes in 1996 was in excess of 1000 tons/year. A more recent 1998 survey by the Virginia Department of Agriculture and Consumer Services (unpublished data) produced a similar sum.

Wine grape variety evaluations at the AHS AREC, Winchester, Virginia:

Evaluating the potential merits of novel wine grapes is a long-term endeavor. Independent grape producers - those who have no intention of owning their own winery - are generally discouraged from "experimenting" with obscure or novel varieties; there are no guarantees that wineries will buy these grapes. State and federal agricultural agencies can provide the long-term commitment needed to fully evaluate the viticultural and enological merits of novel varieties. Winery owners, often on their own initiative, have also provided significant viticultural evaluations of novel grape varieties, and market evaluation of the resulting wines. Those who aspire to commercially evaluate a novel variety are encouraged to plant enough vines (minimum of 100 to 200) to provide a sufficient quantity of fruit for commercial wine production. Readers are also advised that federal, and in some cases, state laws govern the importation and culture of foreign plant material. The National Grapevine Importation Program in Davis, California, was established to facilitate the commercial entry of foreign Vitis germplasm into the United States.

The research basis for some of the varietal recommendations made in this bulletin was a wine grape evaluation planting established in 1989 at Virginia Tech's Alson H. Smith Agricultural Research and Extension Center (AHS AREC) in Winchester, Virginia. The planting was funded by the Virginia Winegrowers Advisory Board. The varieties evaluated at the AHS AREC vineyard are listed in Appendix A. Our results should compare favorably to other sites with generally similar soils, climates and cultural management.

The vineyard was situated at 960 to 1000 feet above sea level with an eastern exposure and slopes of 8 to 12%. The soil was a Frederick-Poplimento loam, primarily limestone-derived with some contribution from sandstone deposits. The effective rooting zone was greater than 40 inches deep. Soil pH was slightly acidic to neutral (i.e., 6.0 to 7.0). Frederick-Poplimento loams have moderately available water capacity. All vinifera varieties were grafted to the rootstock C-3309; hybrids were ungrafted. Vines were planted 7 feet apart in rows 12 feet wide and were evaluated for up to 8 fruiting years. All vines were trained to a bi-lateral cordon 40 inches above ground and spur-pruned. Shoots were thinned after budbreak to 5 shoots per foot of row (35 per vine) and were positioned vertically upright during the growing season. Crop was reduced on extremely fruitful varieties in order to target a crop of approximately 5.0 tons/acre equivalent. Ground cover management, under-trellis weed control, pesticide spraying, and other cultural practices were comparable to those recommended for the region (Wolf and Poling, 1996).

The site and soil features, as well as cultural practices used, resulted in large, vigorous grapevines. Cane pruning weights for all varieties, with the exception of Norton (0.23 lbs/foot of row), averaged greater than 0.35 pounds of cane prunings per foot of row (>2.4 pounds/vine). Those vine sizes were obtained despite one to three shoot hedgings per season. Some of the more vigorous varieties, such as Cabernet Sauvignon, averaged greater than 0.7 pounds of prunings per foot of row. In retrospect, the 7-foot vine spacing-typical for the industry at the time-was too close for many of the varieties. Thus, in forming one's own planting decisions, one must carefully consider vine spacing, and the resultant vine size.

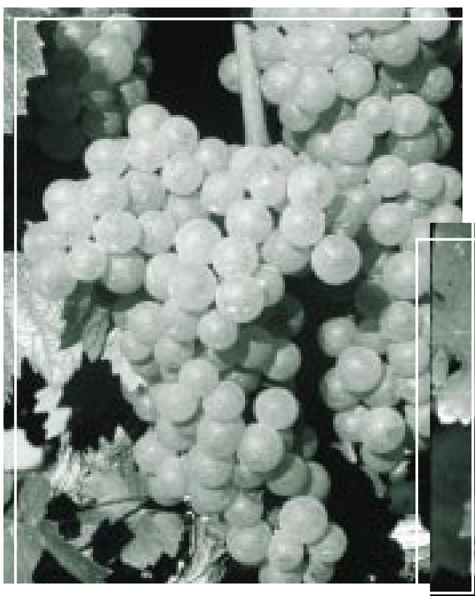
Cold injury is the primary threat to *V. vinifera* production in the Piedmont and Mountain regions of Virginia. Understanding the limits of cold injury avoidance and tolerance of grape varieties is therefore a critical component of the varietal decision. Cold hardiness, that is the ability to acclimate to and resist cold injury, was assessed by two means in the course of our variety evaluations. Laboratory tests of dormant bud cold hardiness were conducted for certain varieties during each winter. Dormant buds were used because they are typically the most cold-tender tissue on the vine, and their cold hardiness can be quickly and accurately assessed (Wolf and Cook, 1994). Cold hardiness varies throughout the dormant period. In our tests, maximum cold hardiness of dormant buds was usually obtained in early January, but occasionally as late as mid-February. Not all varieties were laboratory-tested for cold hardiness each winter; however, two or more winters' data were averaged to provide a composite cold hardiness index for most of the varieties described here. Thus, reference to a predicted 50% killing temperature refers to the average mid-winter temperature at which 50% of test buds were killed in two or more controlled freezing tests. In addition to the laboratory tests, field data were collected following a -11°F episode at the research vineyard in January 1994 (Appendix D).

Wine comments:

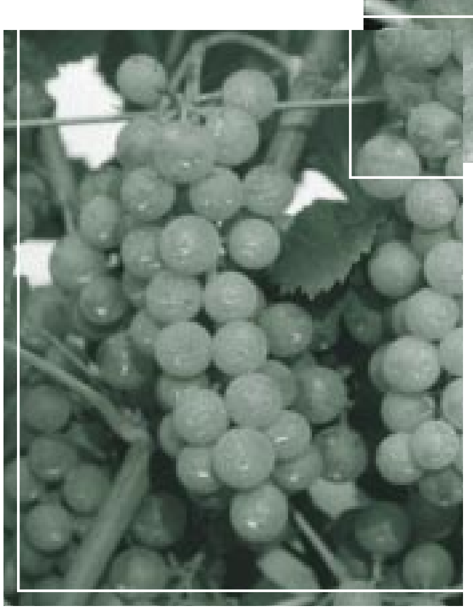
Wines were made from some of the varieties evaluated at the AHS AREC vineyard. Standard, small-lot techniques were used at Virginia Tech's Department of Food Science and Technology for wine evaluations. The resulting wines were informally shared with wine industry members whose opinions of the suitability of a particular wine grape variety were taken into consideration. Wine descriptors are provided; however, varietal aroma, flavor, and wine structure vary quantitatively and qualitatively depending on viticultural and environmental conditions. Production practices that influence wine style are discussed in Zoecklein *et al.* (1995). Comments regarding wine quality and production practices were derived from our observations and those of industry members. Quantitative wine color components and phenol levels for a number of the red-fruited varieties evaluated at the AHS AREC vineyard are provided in Appendix E .

Varieties that can be generally recommended for commercial production

Chardonnay



Cabernet Sauvignon



Chardonel

- Chardonnay
- Viognier
- Muscat Ottonel
- Malvasia bianca
- Cabernet Sauvignon
- Cabernet franc
- Petit Verdot
- Mourvèdre
- Vidal
- Chardonel
- Traminette
- Chambourcin
- Norton

Chardonnay

White, V. vinifera

Chardonnay is the most extensively planted variety in Virginia, accounting for approximately 30 percent of current grape acreage. Chardonnay has performed well in areas as geographically diverse as the Eastern Shore, the rolling hills of the Piedmont, and the higher elevations of the mountain region. A mid-season variety (Appendix B), fruit is ripe about the first week of September in central and eastern areas of Virginia and about one month later at the coolest locations at higher elevations.

Strengths:

- High demand: Demand for high quality Chardonnay fruit is robust and reflects consumer demand for Chardonnay wines. Many Virginia wineries are purchasing Chardonnay fruit.
- Good yields and high fruit quality: Good growers at good to excellent vineyard sites have achieved consistent yields of three to five tons per acre, with high fruit quality. Yields at the AHS AREC in Winchester averaged slightly less than 5 tons/acre over an eight-year period (Table 4).

Weaknesses:

- Early bud break: Early spring budding (Appendix C) increases spring frost hazard. The threat of spring frost can be minimized by prudent site selection.
- Susceptible to winter cold injury: Laboratory freeze tests of vines grown at Winchester predicted that more than 50% primary bud kill could be expected at or below mid-winter temperatures of -7°F. A temperature of -11°F in January 1994 resulted in 100% primary bud kill, but no perceptible trunk injury (Appendix D).
- Susceptible to Botrytis bunch rot: Chardonnay is moderately susceptible to Botrytis bunch rot, caused by the fungus Botrytis cinerea. Botrytis and other fruit bunch rots are particularly severe when fruit is allowed to develop in dense, shaded canopies. Canopy management practices that result in good fruit zone ventilation and fruit exposure reduce the incidence of fruit rots (Smart and Robinson, 1991).
- Susceptible to Grapevine Yellows (GY): Chardonnay is highly susceptible to GY, a lethal disease caused by bacteria-like phytoplasmas (Davis *et al.*, 1998; Wolf *et al.*, 1994). In the absence of knowledge about phytoplasma vectors, effective control of GY is not currently possible, and affected vineyards can lose up to 1% of vines per year. Surveys have shown that vineyards most at risk of GY are located within 5 miles of the Blue Ridge Mountains, and are bordered by native woody species, including *Vitis riparia*, a known alternative phytoplasma host.
- Susceptible to powdery mildew: Chardonnay is highly susceptible to the powdery mildew fungus, *Uncinula necator*. While most of the state's common grape varieties are either moderately or highly susceptible to powdery mildew, the most severe infestations have usually occurred with Chardonnay. Chardonnay producers must therefore be particularly cautious with their protective fungicide program.

Suggested clones: Research with Chardonnay at the Winchester AREC is limited to the University of California's Foundation Plant Materials Service (FPMS) clones #4 and #16. Clone #16 is not recommended in Virginia due to very low yields (data not shown) and greater rot susceptibility. Clone #4 is comparable to or identical to most of the Chardonnay currently grown in Virginia, and is consistently one of the highest yielding clones. Research in other areas suggests that lower yielding clones may offer different, if not superior, wine quality to that of clone #4. Other Chardonnay clones worthy of consideration include, but are not limited to, clone #5, #6, #15 (FPMS, Davis, California), #25 (Geisenheim, Germany), #75, #76, #95, and #96 (Dijon, France).

Suggested spacing and training: Chardonnay is adaptable to either upright shoot growth or downward shoot positioning, and either cane pruning or spur pruning. The most common training system in Virginia is bi-lateral cordon training with spur pruning, and vertical (upright) shoot positioning. Viable alternatives are Smart-Dyson or Smart-Dyson Ballerina, Geneva Double Curtain, or open lyre.

Wine comments: Chardonnay is considered a premium grape variety and is typically produced as a varietal wine. It is planted throughout the world due to its adaptability to various soils and climates. Fruit is suited to a wide range of wine styles from sparkling wine cuvées (base wines) to semi-dry to Burgundy style products rich in complex winemaking bouquets derived from the interactions of yeast, bacteria and wood. Mature, cold fruit is commonly whole cluster-pressed or crushed with limited and controlled skin contact.

Varietal descriptors include apple, tobacco, grapefruit, lime, melon, and peach. Not recommended for home wine production due to disease and winter cold injury susceptibility.

Table 4. Harvest date, fruit harvest chemistry, components of crop yield, and fruit rot severity at harvest for Chardonnay, clone FPMS #4, as grown at the AHS AREC vineyard in Winchester, VA.

		Fruit chemistry						
Year	Harvest date	°Brix	Titratable acidity (g/L)[v]	pH[w]	Berry wt. (g)	Cluster wt. (lb)	Crop yield (t/a)[x]	Rot severity (%)[y]
1991	3 Sep	23.7	4.2	3.54	1.5	0.35	5.6	.
1992	25 Sep	20.7	5.9	3.24	1.8	0.49	5.3	7.1
1993	30 Sep	21.6	5.4	3.64	1.8	0.47	5.9	3.4
1994[z]	21 Sep	21.8	7.5	3.21	2.0	0.33	0.4	.
1995	2 Oct	20.6	6.8	3.72	1.6	0.52	7.5	<1.0
1996	7 Oct	21.2	7.6	3.72	2.0	0.32	3.7	18.1
1997	7 Oct	22.6	6.5	3.27	2.0	0.45	3.9	9.3
1998	15 Sep	22.7	8.3	3.65	1.7	0.41	5.6	1.3
Mean	25 Sep	21.9	6.5	3.50	1.8	0.42	4.8	6.7

v Total titratable acidity expressed as tartaric acid equivalents.
w Analyses conducted on previously frozen berry samples which raises pH 0.1 to 0.2 pH units (Spayd *et al.*, 1987).
x Based on the equivalent of 519 vines per acre with vine spacing used in this project.
y A visual estimate of the overall (per vine) amount of rotted fruit (non-specific) on a 0 to 100% basis.
z Reduced crop yield due to cold injury associated with -11°F on 19 January 1994 (Appendix D).
. Missing data.

Viognier

White, V. vinifera

Historically, the production of Viognier was confined almost exclusively to the Rhone Valley of France, in particular the Condrieu appellation in the Rhône Valley. As late as 1986, Condrieu had barely 50 acres of Viognier. That acreage has since increased to 240. Worldwide, Viognier acreage is still relatively small, but increasing. France reportedly leads with around 1000 acres, California about 500 acres, Virginia less than 30. An early-season variety (Appendix B).

Strengths:

- Good demand: Consumer interest in Viognier wines is strong; however, relatively few Virginia wineries are currently purchasing Viognier fruit.
- Excellent fruit quality: Viognier tends to be a high sugar accumulating variety. Overall fruit quality has been good to excellent (Table 5).
- Good bunch rot resistance: Viognier has excellent resistance to fruit splitting and bunch rots (Table 5).

Weaknesses:

- Early bud break: Average Viognier budbreak was about 3 days later than Chardonnay (Appendix C). Plant only in excellent sites, not subject to spring frost injury.
- Susceptible to winter cold injury: Laboratory freeze tests of vines grown at Winchester predicted that more than 50% primary bud kill could be expected at or below midwinter temperatures of -11°F. Among *V. vinifera* varieties, this hardiness level appears good; however, the hardiness is likely based chiefly on an assessment of secondary buds (see below). A temperature of -11°F in January 1994 resulted in 100% primary bud kill, but no perceptible trunk injury (Appendix D).
- Weak growth: Vine growth can be weak, and slow to fill the trellis.
- Modest yields: Crop yields at the AHS AREC have averaged less than 3 tons per acre. The principal reason for this low yield appears to be primary bud necrosis. Bud necrosis is a physiological disorder that is manifested as the death of buds early in the season of their initiation (Vasudevan *et al.*, 1998a). Other varieties that experience high levels of bud necrosis include Riesling and Syrah (Vasudevan *et al.*, 1998b). Viognier grown at the AHS AREC has averaged 40% to 60% primary bud necrosis each year. Abortion of the primary buds appears to result in increased fruitfulness of secondary buds. For example, although 100% of primary buds were destroyed by a combination of bud necrosis and cold injury in January 1994 (Appendix D), Viognier yielded an average of 3.0 tons/acre equivalent (Table 5).

Suggested clones: No specific recommendations. Viognier evaluated at the AHS AREC vineyard in Winchester was obtained from the New York Agricultural Experiment Station in Geneva, NY (Appendix A) which had, in turn, obtained the material in 1976 from Bordeaux France as clone #12.

Suggested spacing and training: Viognier is adaptable to either upright shoot growth or downward shoot positioning, and either cane pruning or spur pruning. The most common training system in Virginia is bi-lateral cordon training with spur pruning, and vertical (upright) shoot positioning. Viable alternatives are Smart-Dyson or Smart-Dyson Ballerina, Geneva Double Curtain, or open lyre. Canopy division should be carefully considered, as Viognier vine size and vigor are not as great as with other *V. vinifera* varieties, and vine growth may not be sufficient to warrant canopy division.

Wine comments: Viognier is typically produced as a varietal wine, and likely commands the greatest value when produced as such. Viognier wines are typically high in color, alcohol, and body with distinctive varietal aromas of apricots and peaches. Its slight muskiness is reminiscent of Gewürztraminer. Aromas and flavors only develop in the fruit at relatively high sugar levels. As sugar approaches 23° Brix or higher there is a large increase in varietal aroma/flavor; skin phenols and acidity drop rapidly. This corresponds to a change in color of the fruit from green to yellow. As with many varieties, the back side of clusters or shaded clusters have limited varietal character. Optimum grapevine canopy management and synchronous ripening are important in maximizing the varietal character of this grape. As is the case with all white varieties, grapes should be chilled prior to pressing to help preserve the delicate varietal aromas and to limit the extraction of phenols from the skins. Viognier is frequently whole cluster-pressed to reduce phenol extraction, a process that can also limit the extent and intensity of the varietal character. To produce a more varietally assertive wine some vintners use controlled pre-fermentation skin contact. Light pressing and/or the segregation of press fractions is important to limit phenol content and to create a structurally balanced product. Many select a yeast which is not too vigorous and avoid a malo-lactic fermentation or use low diacetyl strains of malo-lactic bacteria. Most producers attempt to highlight varietal aromas and limit bouquet enhancing features such as barrel fermentation in new oak and sur lie storage. Varietal descriptors include fresh aromas of honeysuckle, melon, orange, muscat, pears, cloves, honey, and tropical fruits. Not recommended for home wine production due to disease and winter cold injury susceptibility.

Table 5. Harvest date, fruit harvest chemistry, components of crop yield, and fruit rot severity at harvest for Viognier, as grown at the AHS AREC vineyard in Winchester, VA.

		Fruit chemistry						
Year	Harvest date	°Brix	Titratable acidity (g/L)[v]	pH[w]	Berry wt. (g)	Cluster wt. (lb)	Crop yield (t/a)[x]	Rot severity (%)[y]
1992	2 Oct	22.6	.	3.81	1.4	0.44	3.2	< 1.0
1993	29 Aug	23.3	6.0	3.58	1.8	0.24	1.6	0
1994[z]	13 Sept	23.4	6.0	3.19	1.7	0.32	3.0	0
1995	16 Oct	24.7	3.8	4.21	1.7	0.37	4.7	1.0
1996	15 Oct	21.2	6.9	3.90	1.6	0.16	1.3	1.4
1997	24 Sept	23.7	5.7	3.62	1.8	0.33	3.4	< 1.0
1998	9 Sept	24.1	6.0	3.90	1.5	0.23	3.2	0
Mean	24 Sept	23.3	5.7	3.74	1.6	0.30	2.9	0.7

v-z Footnotes identical to those in Table 4.

Muscat Ottonel

White, V. vinifera

Muscat Ottonel is one of several potentially suitable Muscats. These varieties are characterized by the unique and distinguishable Muscat flavor. Muscat Ottonel, a relatively new variety, is grown in small quantities worldwide, notably the Alsace region of France. A similar muscat worthy of trial in Virginia is Muscat blanc. Muscat Ottonel is an early-season variety (Appendix B).

Strengths:

- Bud break: Bud break is about 6 days later than that of Chardonnay, which affords some frost avoidance (Appendix C).
- Pronounced floral aroma: Muscat Ottonel produces intensely scented, perfumed wines. Grapes produce exceptional dessert style wines, and can be used to improve less fruity wines by blending. Good resistance to fruit rots (Table 6).

Weaknesses:

- Susceptible to winter cold injury: Laboratory freeze tests of vines grown at Winchester predicted that more than 50% primary bud kill could be expected at or below mid-winter temperatures of -9°F. A temperature of -11°F in January 1994 resulted in 74% primary bud kill, but no perceptible trunk injury (Appendix D).
- Modest yields: average of 3 tons/acre (Table 6).
- Uncertain demand: Not strongly recommended for independent growers because of uncertain winery demand.

Suggested clones: No specific recommendations. The clone evaluated at the AHS AREC in Winchester was obtained from the FPMS at Davis, CA as clone #1 (Appendix A).

Suggested spacing and training: Cordon training with spur-pruning and vertical, upright shoot positioning was used at AHS AREC in Winchester. We lack experience with other systems.

Wine comments: Of the three muscat-type varieties grown in France, Muscat Ottonel is the palest in terms of color and aroma/flavor intensity. The grape can be used to produce a dry wine, although this is uncommon due to phenol-derived bitterness, low acidity and high pH. Muscat Ottonel is used to make semi-dry, sweet table and dessert-style wines and as a blending component. Controlled skin contact can enhance the aroma and flavor intensity but may increase astringency and bitterness. Because of the aromatic intensity of the variety, it can be used to produce a muté (stable juice with or without alcohol fortification for blending) or as a blender to add floral "notes" to more neutral varieties. It is not uncommon to rinse the pomace of Muscat Ottonel with neutral juice or wine to aid in the extraction of grape varietal aroma and flavors. Pomace rinsing is also done with fortifying alcohol to create a muté. Varietal descriptors include grapey, roses, and spices. Not recommended for home wine production due to disease and winter cold injury susceptibility.

Table 6. Harvest date, fruit harvest chemistry, components of crop yield, and fruit rot severity at harvest for Muscat Ottonel, as grown at the AHS AREC vineyard in Winchester, VA.

		FRUIT CHEMISTRY						
Year	Harvest date	°Brix	Titratable acidity (g/L)[v]	pH[w]	Berry wt. (g)	Cluster wt. (lb)	Crop yield (t/a)[x]	Rot severity (%)[y]
1991	26 Aug	19.3	2.2	4.08	2.0	0.21	4.1	.
1992	18 Sept	20.3	3.0	3.36	2.6	0.22	2.4	2.4
1993	7 Sept	21.7	3.4	3.52	2.5	0.27	4.0	< 1.0
1994[z]	16 Sept	20.6	3.6	3.82	2.3	0.19	2.0	1.8
1995	22 Sept	21.7	4.0	4.05	2.4	0.34	4.9	0
1996	19 Sept	19.1	4.2	4.01	2.6	0.20	1.1	< 1.0
1997	16 Sept	21.3	3.5	3.61	2.5	0.23	3.2	< 1.0
1998	1 Sept	21.3	4.7	4.10	2.4	0.15	2.0	0.0
Mean	10 Sept	20.7	3.6	3.82	2.4	0.23	3.0	0.9

v-z Footnotes identical to those in Table 4.

Malvasia bianca

White, V. vinifera

Like Muscat Ottonel, Malvasia bianca comes from a diverse family and produces aromatic wines. It is grown in many areas, including Virginia and California, and may be best known as a Denominazione di Origine Controllata (DOC)-permitted bouquet contributor to some Chianti wines. An early-season variety (Appendix B).

Strengths:

- Bud break: Bud break is about 7 days after Chardonnay (Appendix C).
- Pronounced floral aroma: The comments on Muscat Ottonel also apply for Malvasia bianca.
- Good yields: Crop yields have averaged 4.8 tons/acre; greater than Muscat Ottonel and comparable to Chardonnay. Malvasia bianca has one of the largest clusters among all varieties grown at the AREC vineyard (Table 7).

Weaknesses:

- Compact clusters: Malvasia has very tight, compact clusters which could increase its susceptibility to bunch rots. Our experience at the AHS AREC vineyard, however, suggests that Malvasia bianca is no more prone to bunch rots than is Chardonnay (Table 7).
- Susceptible to winter cold injury: Laboratory freeze tests of vines grown at Winchester predicted that more than 50% primary bud kill could be expected at or below mid-winter temperatures of -9°F. A temperature of -11°F in January 1994 resulted in 95% primary bud kill, and trunk injury to 2 of 14 plants (Appendix D).
- Uncertain demand: Not strongly recommended for independent growers because of uncertain winery demand.

Suggested clones: No specific recommendations. The clone evaluated at the AHS AREC in Winchester was obtained from the FPMS at Davis, CA as clone #3 (Appendix A).

Suggested spacing and training: Cordon training with spur-pruning and vertical, upright shoot positioning was used at AHS AREC in Winchester. We lack experience with other systems.

Wine comments: Malvasia bianca is used to produce dry, off-dry and sweet, dessert-style wines. Fruit can also be used for producing sparkling wine bases. Controlled skin contact can enhance the aroma and flavor intensity but may increase astringency and bitterness. Because of the aromatic potential of this variety, it can be used to produce a muté (stable juice with or without alcohol fortification) or as a blender to add floral "notes" to more neutral varieties. It is not uncommon to rinse the pomace of this high-terpene variety with neutral juice, wine or alcohol used for fortification in muté production. Varietal descriptions include floral and fruity. Not recommended for home wine production due to disease and winter cold injury susceptibility.

Table 7. Harvest date, fruit harvest chemistry, components of crop yield, and fruit rot severity at harvest for Malvasia bianca, as grown at the AHS AREC vineyard in Winchester, VA.

		Fruit chemistry						
Year	Harvest date	°Brix	Titratable acidity (g/L)^{V}	pH^{W}	Berry wt. (g)	Cluster wt. (lb)	Crop yield (t/a)^{X}	Rot severity (%)^{Y}
1991	26 Aug	16.7	3.5	3.68	2.31	0.52	6.5	.
1992	25 Sept	19.5	4.8	3.25	3.36	0.77	3.9	4.5
1993	7 Sept	20.5	5.6	3.24	3.46	1.07	6.2	< 1.0
1994^{Z}	16 Sept	19.2	5.3	3.55	3.44	0.66	1.0	4.4
1995	22 Sept	20.6	5.3	3.48	3.49	1.00	7.6	< 1.0
1996	19 Sept	18.7	6.1	3.58	4.00	0.57	2.0	< 1.0
1997	7 Oct	22.0	5.0	3.30	3.80	0.82	5.7	< 1.0
1998	1 Sept	19.1	5.6	3.69	3.92	0.74	5.7	< 1.0
Mean	15 Sept	19.5	5.2	3.47	3.47	0.77	4.8	2.0

v-z Footnotes identical to those in Table 4.

Cabernet Sauvignon

Red, V. vinifera

Cabernet Sauvignon represents about 12 percent of Virginia grape acreage. Cabernet Sauvignon is one of the principal red Bordeaux varieties and has performed reasonably well under a wide range of Virginia's growing conditions. Vines have a long vegetative cycle, with late-season fruit maturity (Appendix B), and are recommended only for sites that have at least 180 frost-free days per year.

Strengths:

- High demand by wineries: Demand by wineries for high quality Cabernet Sauvignon fruit is strong.
- Late bud-break: Bud-break occurs about 10 days after Chardonnay (Appendix C).
- Good yields: Cabernet Sauvignon clone #7 averaged 4.5 tons/acre at Winchester (Table 8). The average Cabernet Sauvignon yield attained in 1988 among the top 50% of Virginia's commercial producers was 3.9 tons per acre (data not shown).
- Good rot resistance of fruit: Cabernet fruit is decidedly more resistant to cracking and rots than many other commonly grown varieties (Table 8 and 9).

Weaknesses:

- Abundant vegetative growth: Cabernet Sauvignon is one of the most vigorous varieties commonly grown in Virginia. Unless adequately accommodated by an appropriate vine spacing and training system, this luxurious growth can cause canopy shading and related problems with increased disease incidence, poor fruit/wine color, elevated fruit titratable acidity, and reduced varietal character. Wide in-row spacing, use of rootstocks that impart low vigor, avoidance of fertile soils, divided canopy training, and remedial canopy management measures to promote fruit exposure are all reasonable means of dealing with this potential vigor.
- Susceptible to winter cold injury: Laboratory freeze tests of vines grown at Winchester predicted that more than 50% primary bud kill could be expected at or below mid-winter temperatures of -6°F. A temperature of -11°F in January 1994 resulted in 100% primary bud kill, with trunk injury on 2 of 15 vines of clone #6 (Appendix D). Cabernet Sauvignon should only be planted in excellent sites where temperatures lower than -6°F are rare or absent. Avoid poorly drained soils. Even small areas of poor drainage, such as dips and depressions in the vineyard, can be associated with increased cold injury and crown gall expression.
- Late-season bunch stem necrosis can reduce crop: Late-season bunch stem necrosis (BSN) is manifest as a withering and death of a portion of the

Table 8. Harvest date, fruit harvest chemistry, components of crop yield, and fruit rot severity at harvest for Cabernet Sauvignon, clone #7, as grown at the AHS AREC vineyard in Winchester, VA.

		FRUIT CHEMISTRY						
Year	Harvest date	°Brix	Titratable acidity (g/L)[V]	pH[W]	Berry wt. (g)	Cluster wt. (lb)	Crop yield (t/a)[X]	Rot severity (%)[y]
1991	17 Sept	22.3	3.4	3.76	1.4	0.23	4.4	.
1992	21 Oct	20.6	6.0	3.29	1.5	0.31	4.7	<1.0
1993	18 Oct	22.4	5.4	3.71	1.5	0.32	5.4	< 1.0
1994[Z]	27 Oct	22.0	5.2	3.72	1.3	0.22	1.8	0.0
1995	13 Oct	20.2	4.8	3.87	1.4	0.28	5.3	0.0
1996	25 Oct	19.6	7.8	3.76	1.6	0.31	5.0	< 1.0
1997	14 Oct	21.7	5.1	3.32	1.6	0.29	5.7	0.0
1998	13 Oct	21.6	4.3	4.03	1.6	0.27	4.0	0.0
Mean	15 Oct	21.3	5.3	3.68	1.5	0.28	4.5	0.4

v-z Footnotes identical to those in Table 4.

cluster stem (rachis) at or shortly after veraison. The disorder is not unique to Virginia and likely results from several causes. In severe cases, 50% or more of clusters may be affected, with a crop loss of 20% or more. The causes of late-season BSN appear to be associated with moisture, nutritional, or other stresses. Partial control has been reported in some viticultural regions by foliar applications of magnesium sulfate, directed at the clusters, during mid- to late- summer. Recent research at the AHS AREC vineyard associated BSN incidence in that vineyard with inadequate tissue nitrogen levels. Application of nitrogen fertilizer remedied the problem. The mineral nutritional needs of vines must, however, first be examined through a combination of visual assessment and tissue analysis.

Suggested clones: Two Cabernet Sauvignon clones were evaluated at Winchester: FPMS clone #6 and FPMS clone #7 (Formerly #8). Vineyard data for both are included in Tables 8 and 9, respectively. We chose those clones because they were roughly on opposite ends of the crop yield range; clone #7 being a high producer, clone #6 being a relatively low crop producer (Wolpert *et al.*, 1995). Clone #7 at Winchester averaged 4.5 tons/acre (Table 8), while clone #6 averaged 2.8 tons/acre (Table 9). Yield differences were due principally to berries per cluster (not shown) and berry weight. Our fruit chemistry data were comparable to the California data (Wolpert *et al.*, 1995); the higher yields of the clone #7 were associated with a slightly lower Brix level at harvest compared to the clone #6. Either clone #6 or clone #7 could be recommended in Virginia, the main difference is one of yield.

Suggested spacing and training: Wide in-row vine spacing (8 to 10 feet) and/or open-lyre training are recommended to accommodate vine growth. Cordon training and spur-pruning are recommended. Shoots are moderately to strongly upright growing, and tend to push lateral shoots when forced to grow horizontally or downward. For these reasons, vertically upright shoot-positioned training and trellis systems are recommended.

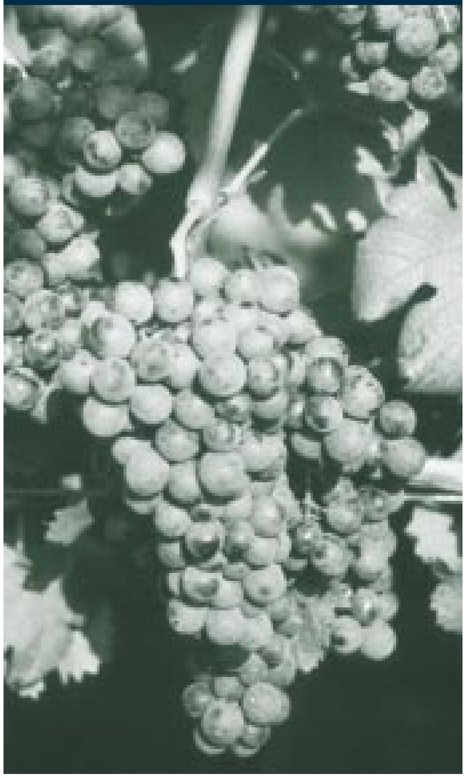
Wine comments: Cabernet Sauvignon is produced as a varietal wine and is also used in Bordeaux style blends. This vigorous variety tends to produce fruit with a high pH, especially if over-cropped or during dry seasons. The wine can be robust and full-bodied with aging potential. It is produced with and without pre-fermentation maceration, and either with or without extended post-fermentation skin contact. Some vintners use Cabernet Sauvignon in barrel fermentation programs. Wines from immature or shaded clusters can have assertive herbal elements usually described as green bean, eucalyptus and green pepper. It is essential that grapes be fully matured to provide ripe, supple tannins. It is often desirable to chaptalize (add sugar) to obtain an alcohol level high enough to support the tannin structure. In Bordeaux style blends, Cabernet Sauvignon provides structural tannins, rich mouth feel and fullness to the body. Wines made with mature fruit have the ability to develop an intense and complex bottle bouquet. Of the two Cabernet Sauvignon clones evaluated in Virginia, Clone #6 produces a wine with greater color, better phenol structure and more varietal aroma intensity compared to wines of clone #7 (Appendix E). Varietal descriptors include cedar, mint, plum, black currant (cassis), green bell pepper, eucalyptus, and black cherry. Not recommended for home wine production due to disease and winter cold injury susceptibility.

Table 9. Harvest date, fruit harvest chemistry, components of crop yield, and fruit rot severity at harvest for Cabernet Sauvignon, clone #6, as grown at the AHS AREC vineyard in Winchester, VA.

		Fruit chemistry						
Year	Harvest date	°Brix	Titratable acidity (g/L)[v]	pH[w]	Berry wt. (g)	Cluster wt. (lb)	Crop yield (t/a)[x]	Rot severity (%)[y]
1991	6 Sept	22.7	3.4	3.46	1.2	0.16	2.8	.
1992	21 Oct	21.9	4.9	3.31	1.1	0.18	2.6	< 1.0
1993	18 Oct	23.3	5.2	3.72	1.3	0.16	2.9	< 1.0
1994[z]	27 Oct	23.4	4.6	3.78	1.1	0.15	1.8	0.0
1995	13 Oct	20.7	5.3	3.85	1.1	0.17	3.8	0.0
1996	25 Oct	20.4	7.3	3.85	1.3	0.13	2.5	0.0
1997	14 Oct	22.3	5.3	3.31	1.3	0.15	3.2	0.0
1998	13 Oct	21.4	4.7	3.96	1.2	0.16	3.0	0.0
Mean	13 Oct	22.0	5.1	3.66	1.2	0.16	2.8	0.3

v-z Footnotes identical to those in Table 4.

Cabernet franc



Cabernet franc

Cabernet franc is another red Bordeaux variety and has gained acreage in Virginia within the last few years. Vegetative growth, yields, and fruit quality are similar to Cabernet Sauvignon. One distinction between these two varieties, however, is the somewhat greater cold hardiness of Cabernet franc. Late-season crop maturity (data not shown).

Strengths:

- Good yields: The comments provided for Cabernet Sauvignon apply here.
- Good rot resistance of fruit: Cabernet franc fruit ripens several days to a week or more earlier than Cabernet Sauvignon fruit. Fruit is fairly resistant to bunch rots.
- Greater cold hardiness than Cabernet Sauvignon: Grower experience as well as controlled cold hardiness comparisons of dormant buds (Wolf and Cook, 1991) indicate that Cabernet franc can have up to several degrees (F) greater cold hardiness than Cabernet Sauvignon.
- Good demand by wineries: Cabernet franc is a relative newcomer to Virginia viticulture, but demand for the fruit is anticipated to remain steady or increase in future years.

Weaknesses:

- Excessive vegetative growth: The comments made above about Cabernet Sauvignon growth characteristics can also be applied to Cabernet franc.
- Prevalence of leafroll virus in much of propagative stock: Leafroll virus can reduce yields, fruit quality, and perhaps the cold hardiness of affected vines. Leafroll is present in as much as 30% of the commonly available Cabernet franc planting stock. Leafroll symptoms become obvious in mid- to late-summer as a downward rolling of leaf margins and a reddening of the interveinal regions of leaves. Buy disease-free certified nursery stock or collect budwood from vines that were marked during the growing season as being visually free of leaf roll symptoms. The purchase of “certified disease-free” nursery stock has not always prevented the introduction of leaf roll-affected vines.
- Early budbreak: This is not a serious weakness, but the early budbreak of Cabernet franc (Appendix C) might be of concern in areas prone to spring frosts.
- Bunch stem necrosis (BSN) can reduce yields: Our current understanding of BSN is described under Cabernet Sauvignon.

Suggested clones: The most commonly used Cabernet franc clone has been FPMS #1. Comparative evaluations with FPMS #1 and other clones are currently in progress at the AHS AREC in Winchester.

Suggested spacing and training: Shoots are strongly upright growing, and tend to push lateral shoots when forced to grow horizontally or downward. For these reasons, vertically upright shoot-positioned training and trellis systems are recommended. Wide in-row vine spacing (8 to 10 feet) and/or open-lyre training are recommended to accommodate vine growth.

Wine comments: Cabernet franc, considered a variety of somewhat lesser quality to Cabernet Sauvignon, has done well in Virginia. Cabernet franc can be produced as a 100% varietal or blended with a wide variety of other wines. The wine typically has vegetal aromas and flavors that may reduce overall complexity. Ripe fruit and sun exposure help to minimize the concentration of methoxypyrazines, compounds partially responsible for the assertive, herbal character. Non-blended Cabernet franc wine frequently lacks the desired broad spectrum of aromas, flavors and tannin structure. Trials currently in progress suggest that Cabernet franc wines may benefit from pre-fermentation tannin additions. Varietal descriptors include cherry, herbal (clove, dill, spice), berry-like aromas. Herbal character can be very assertive in fruit that is not optimally ripened. Not recommended for home wine production due to disease and winter cold injury susceptibility.

Petit Verdot

Red, V. vinifera

Petit Verdot has been one of our more promising, alternative red varieties in the wine grape variety evaluation program at the AHS AREC. Petit Verdot is another of the principal red varieties produced in Bordeaux. And like Cabernet franc, Petit Verdot's greatest merits may lie in its blending contributions to Bordeaux style wines. Petit Verdot fruit matures late-season (Appendix B).

Strengths:

- Increasing demand: Petit Verdot has gained in popularity since 1990, although there are currently less than 30 acres grown in Virginia.
- Good yields: Yields of Petit Verdot at the AHS AREC vineyard averaged over 5 tons/acre (Table 10).
- Excellent fruit quality: Petit Verdot fruit quality has been exceptional. It has typically produced riper fruit at lower pH and comparable titratable acidity than Cabernet Sauvignon, while averaging greater yields (Table 10).
- Fair cold hardiness: Petit Verdot sustained 95% primary bud kill at -11F in 1994, while Cabernet Sauvignon clone #7 sustained 90% primary bud kill during the same episode. However, the effect on yields was less on Petit Verdot (3.6 T/A) than for Cabernet Sauvignon (1.8 T/A).

Weaknesses:

- Susceptible to winter cold injury: Laboratory freeze tests of vines grown at Winchester predicted that more than 50% primary bud kill could be expected at or below mid-winter temperatures of -8°F. Petit Verdot sustained 95% primary bud kill at -11°F in 1994. Cabernet Sauvignon clone #7 sustained 90% primary bud kill during the same episode. However, the effect on yields was less on Petit Verdot (3.6 tons/acre in 1994) than for Cabernet Sauvignon (1.8 tons/acre) (Appendix D).
- High acid and pH: We have occasionally seen a combination of high fruit pH (e.g., >3.7) and high titratable acidity (e.g., > 8 g/L) with Petit Verdot. In such cases, Petit Verdot may need to be blended.

Suggested clones: No specific recommendations. Evaluations of three Petit Verdot clones are in progress at Winchester.

Suggested spacing and training: Comments made above for Cabernet Sauvignon would likely apply.

Wine comments: If fruit is allowed to fully ripen, the wines are rich, age-worthy and, like Syrah, can have a peppery, spicy aroma profile laced with hints of currants and black cherry. Traditional fruit maturity gauges such as sugar, acid and pH may be inadequate predictors of wine quality. Due to its relatively high tannin levels, fruit maturity is better predicted by tasting of skins for degree of tannin polymerization. Petit Verdot produces a medium- to full-bodied wine that is more tannic and more colored than the other four traditional red Bordeaux varieties. This may require 23-24 °Brix, not usually a problem due to the grape's ability to 'hang' in the vineyard. Petit Verdot

Table 10. Harvest date, fruit harvest chemistry, components of crop yield, and fruit rot severity at harvest for Petit Verdot, as grown at the AHS AREC vineyard in Winchester, VA.

Year	Harvest date	Fruit chemistry °Brix	Titratable acidity (g/L)[V]	pH[W]	Berry wt. (g)	Cluster wt. (lb)	Crop yield (t/a)[X]	Rot severity (%)[Y]
1993	11 Oct	28.4	4.5	3.18	1.0	0.25	5.3	1.3
1994[Z]	18 Oct	24.6	4.3	3.61	1.3	0.27	3.6	< 1.0
1995	23 Oct	23.5	8.1	3.52	1.3	0.25	5.6	< 1.0
1996	31 Oct	24.4	9.3	3.82	1.3	0.20	4.4	< 1.0
1997	16 Oct	24.4	6.5	3.77	1.3	0.20	6.2	< 1.0
1998	5 Oct	23.0	7.3	3.79	1.2	0.19	5.3	0
Mean	15 Oct	24.7	6.7	3.62	1.2	0.23	5.1	0.9

v-z Footnotes identical to those in Table 4.

tends to produce a higher °Brix at lower pH's than Cabernet Sauvignon with a relatively high acid content. The wine tends to be relatively assertive with lots of color (as much as Cabernet Sauvignon [Appendix E]) and dense tannins. As a blender, Petit Verdot adds extra aroma/flavor, alcohol, palate weight (body), tannins and color. Varietal descriptors include berry, strawberry, cinnamon, raspberry and spice (black pepper), rose, and floral. Not recommended for home wine production due to disease and winter cold injury susceptibility.

Mourvèdre

Red, V. vinifera

Mourvèdre (syn. Mataro) is one of the principal red varieties produced in southeast France, especially in the Rhône region. Wines can be made as varietals or, more com' designation is uncertain. Mourvèdre is a late-season variety (Appendix B).

Strengths:

- Late bud break: Mourvèdre breaks buds even later than Cabernet Sauvignon. The time of bud break has averaged about 16 days after that of Chardonnay (Appendix C).
- Good yields: although a substantial reduction in crop occurred following the 1994 winter injury (Appendix D), the average of four harvests from 1994 to 1998 was greater than 4 tons/acre (Table 11). Clusters of Mourvèdre were among the largest of red varieties grown at AHS AREC vineyard (Table 11).

Weaknesses:

- Susceptible to winter cold injury: A temperature of -11°F in January 1994 resulted in 100% primary bud kill (Appendix D). Trunk injury was not rated. Laboratory evaluations of dormant bud cold hardiness have been inconclusive.
- Uncertain demand: Independent grape producers should fully explore market before planting Mourvèdre.
- Late fruit maturation: Should not be planted at sites with less than 180 frost-free days (Appendix A).

Suggested clones: No specific recommendations.

Suggested spacing and training: Cordon training with spur-pruning and vertical, upright shoot positioning has worked well at AHS AREC in Winchester. We lack experience with other systems.

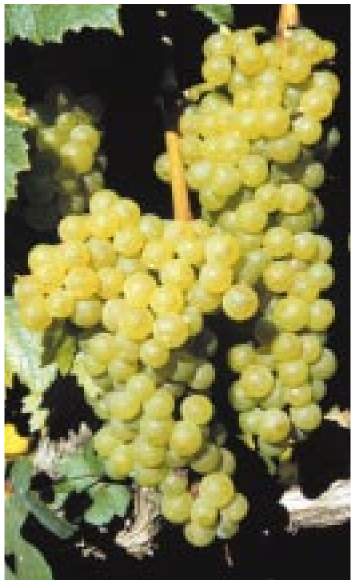
Wine comments: As Spain's second most important red variety, Mourvèdre appears well adapted to warm climates and a wide range of soils. This thick-skinned, relatively low sugar producing variety can make a wine with relatively soft tannins and low anthocyanin concentration (see Appendix E). As with other reds, phenol maturity, including stem lignification, is important. The wine is usually fermented warm to maximize color extraction which can be a problem with this variety. Liquid reduction (bleeding) is used as an aid to improve the color depth. The wine is generally not stored in new oak cooperage. Mourvèdre is frequently used in blends, such as in Chateauneuf-du-Pape, for improving the structural quality. In Virginia, Mourvèdre has been successfully blended with Norton, Syrah and Tannat. Not recommended for home wine production due to disease and winter cold injury susceptibility.

Table 11. Harvest date, fruit harvest chemistry, components of crop yield, and fruit rot severity at harvest for Mourvèdre, as grown at the AHS AREC vineyard in Winchester, VA.

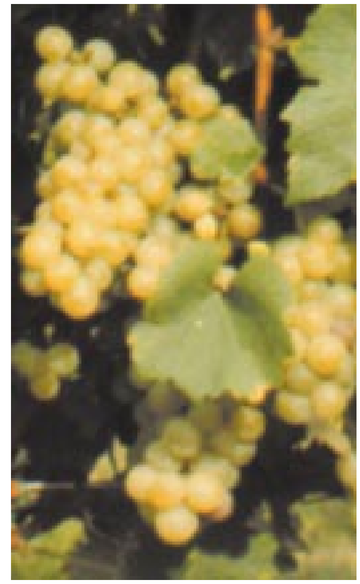
		FRUIT CHEMISTRY						
Year	Harvest date	°Brix	Titratable acidity (g/L)[v]	pH[w]	Berry wt. (g)	Cluster wt. (lb)	Crop yield (t/a)[x]	Rot severity (%)[y]
1994[z]	19 Oct	22.8	5.5	3.54	2.2	0.60	1.5	< 1.0
1995	23 Oct	19.8	6.6	3.86	2.0	0.71	5.7	< 1.0
1996*	.	.	.	.	.	.	.	.
1997	29 Oct	21.7	7.7	3.75	2.2	0.52	4.9	< 1.0
1998	19 Oct	22.2	5.3	4.01	2.2	0.66	5.5	1.7
Mean	23 Oct	21.6	6.3	3.79	2.2	0.62	4.4	<1.2

* 1996 data were lost due to late maturation and severe bird depredation.
v-z Footnotes identical to those in Table 4.

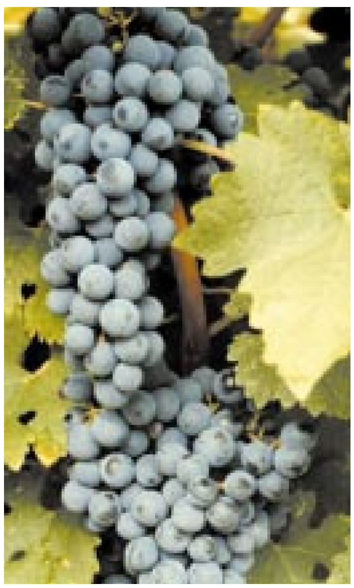
Varieties that can be generally recommended for commercial production

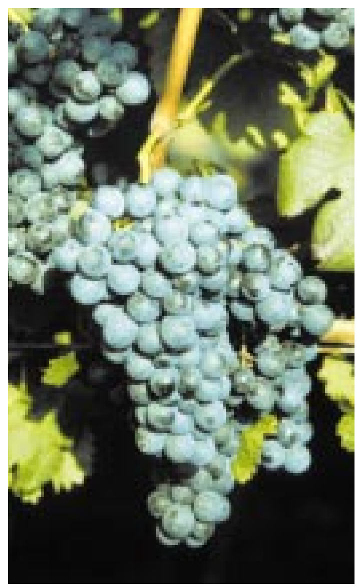

Chardonnay

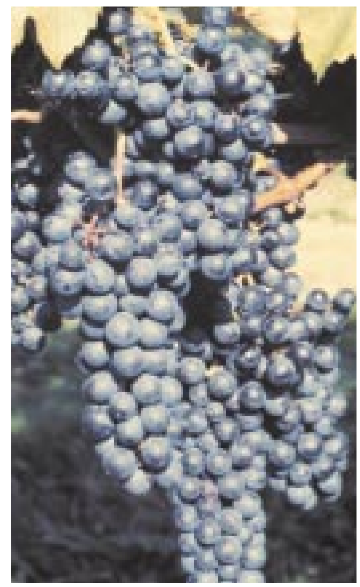

Viognier

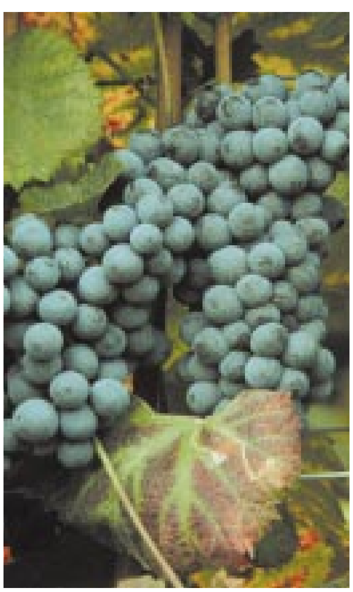

Muscat Ottonel

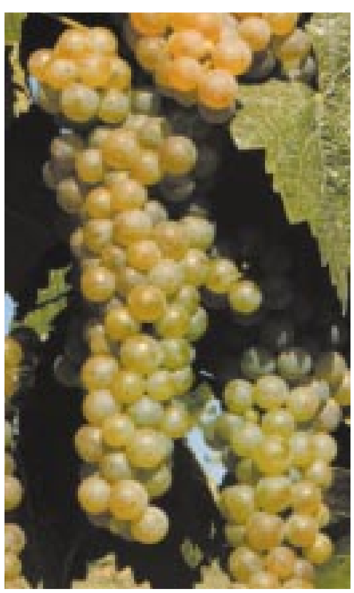

Malvasia bianca

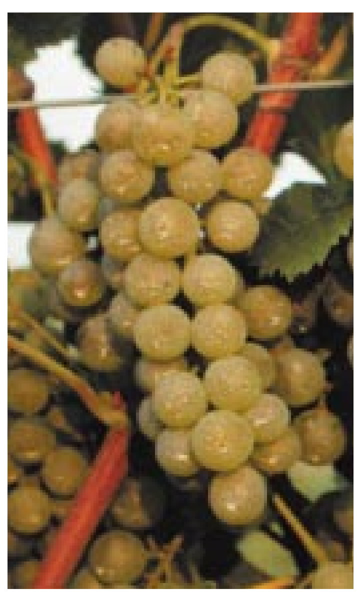

Cabernet Sauvignon

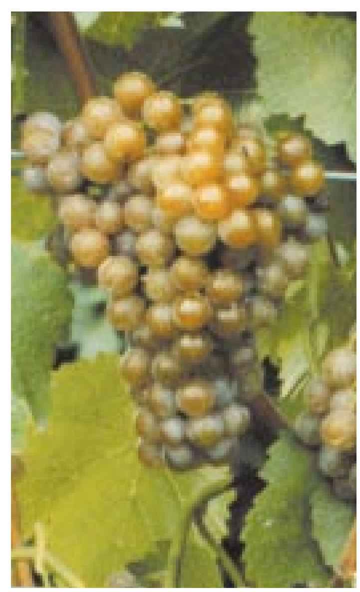

Cabernet franc


Petit Verdot

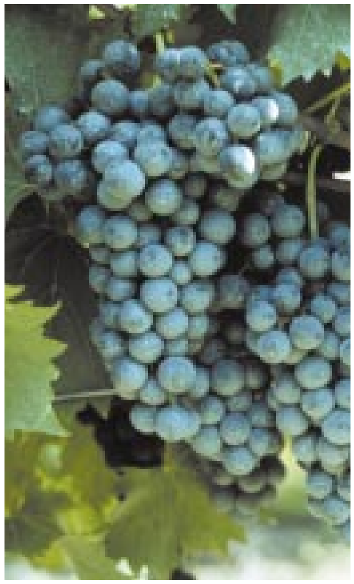

Mourvèdre


Vidal


Chardonel


Traminette

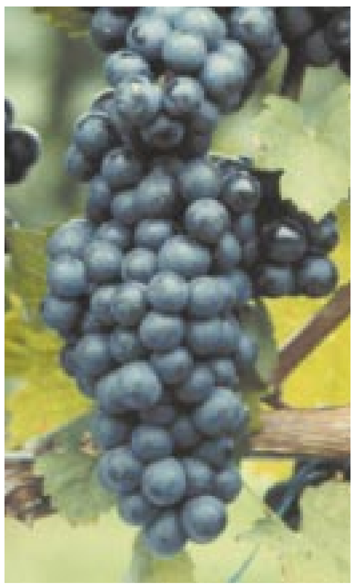
Varieties that can be generally recommended for commercial production (continued)



Chambourcin

Norton

Varieties Not Generally Recommended, But Worthy Of Consideration For Specific Uses Or Only In Exceptional Sites



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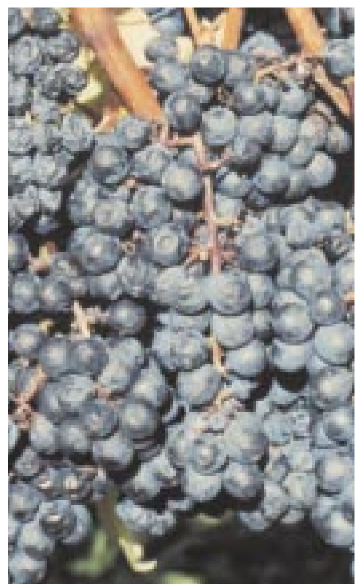
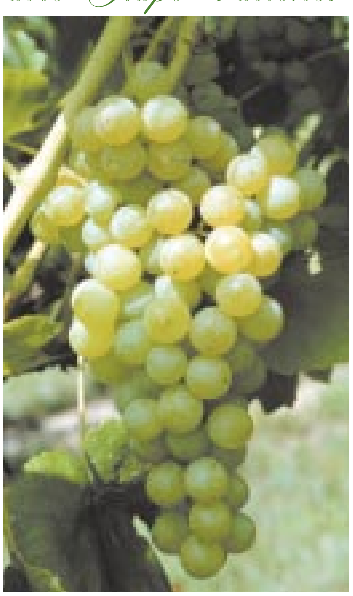


Tannat

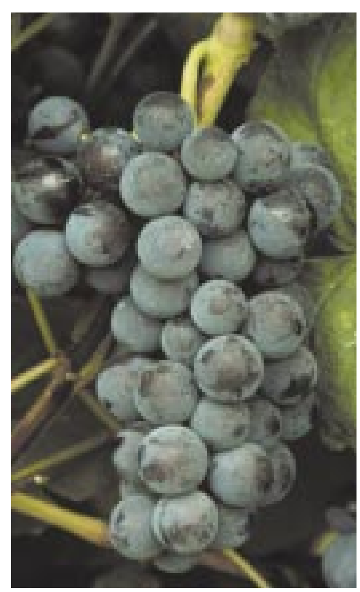
Table Grape Varieties



Himrod

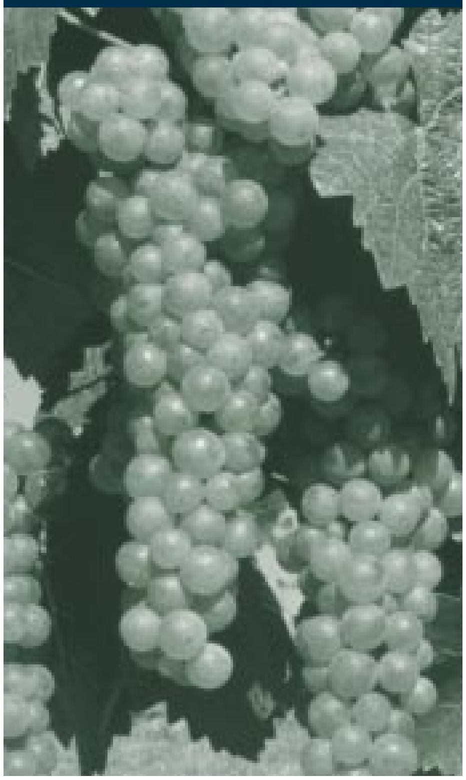
Vanessa

Glenora



Mars

Vidal



White, interspecific hybrid

Vidal (syn. Vidal blanc) represents about 7% of current Virginia grape acreage. Vidal is well suited to a diversity of climatic and soil conditions owing to late bud break and good mid-winter cold hardiness. Late-season fruit maturity (Appendix B).

Strengths:

- Good cold hardiness: As a group, the hybrid varieties, including Vidal, are five or more degrees (F) more cold hardy than any of the common *vinifera* varieties.
- Excellent yields: Vidal yields in 1988 averaged 4.4 tons per acre among the top 50% of Vidal producers (data not shown). Yields at the AHS AREC vineyard have averaged over 6 tons/acre (Table 12). The more consistent yields (due to less winter injury) and larger crops can partially offset the lower price paid per ton.
- Late bud-break: Vidal is a very late bud-breaking variety (Appendix C). This attribute, as well as its relatively good cold hardiness, gives Vidal an advantage in sites that might be prone to late-spring frosts and low winter temperatures.
- Relatively resistant to fruit bunch rots (Table 12).

Weaknesses:

- High fruitfulness can lead to overcropping: Like Seyval, Vidal has a tendency to produce larger crops than the vine can mature. The results of overcropping are chronically stunted vines, low yields, and poor fruit quality. Overcropping can be avoided by proper dormant pruning, followed by additional crop control consisting of shoot thinning, fruit cluster thinning, or a combination of the two. Regular nitrogen fertilizer applications are also generally required to meet the vine's need for this nutrient.
- Viruses can be problematic: Several older Vidal plantings in Virginia have been found to contain Tomato and Tobacco Ringspot Virus-infected vines. These viruses weaken and often kill infected vines. Both viruses can be introduced in infected stock. The viruses can also be transmitted to clean plants in the vineyard by soil nematodes, which acquire the viruses from infected weeds or previous crops. Buy certified disease-free vines and keep the vineyard free of weeds to minimize the threat of viral diseases. Graft Vidal to a pest-resistant rootstock to decrease the likelihood that vines will be infected with virus through nematode feeding. The rootstock C-3309 has shown good field resistance to virus infection (Gonsalves, 1982).

Suggested clones: No specific recommendations.

Suggested spacing and training: Cordon training with spur-pruning and vertical, upright shoot positioning has

Table 12. Harvest date, fruit harvest chemistry, components of crop yield, and fruit rot severity at harvest for Vidal, as grown at the AHS AREC vineyard in Winchester, VA.

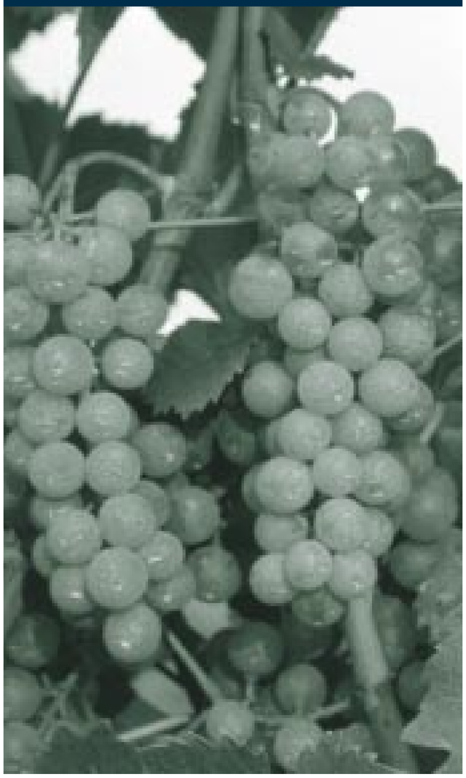
Year	Harvest date	Fruit chemistry: °Brix	Fruit chemistry: Titratable acidity (g/L)[v]	Fruit chemistry: pH[w]	Berry wt. (g)	Cluster wt. (lb)	Crop yield (t/a)[x]	Rot severity (%)[y]
1991	7 Oct	22.0	3.1	3.87	1.6	0.19	2.7	.
1992	2 Oct	22.8	5.9	3.61	1.7	0.38	5.0	3.1
1993	4 Nov	23.6	6.6	3.58	1.8	0.36	7.1	1.1
1994[z]	11 Oct	22.8	5.0	3.44	1.9	0.41	6.8	5.7
1995	23 Oct	21.5	6.4	3.69	1.8	0.42	8.1	< 1.0
1996	22 Oct	24.3	9.0	3.68	1.9	0.34	5.5	< 1.0
1997	14 Oct	23.4	5.6	3.31	1.9	0.42	6.6	< 1.0
1998	21 Sept	22.2	5.5	3.73	1.9	0.49	8.3	1.2
Mean	13 Oct	22.8	5.9	3.61	1.8	0.38	6.3	2.0

v-z Footnotes identical to those in Table 4.

worked well at AHS AREC in Winchester. We lack experience with other systems. Some growers have reported problems keeping viable spurs in the mid-cordon region of Vidal, and have resorted to cane pruning. This problem was not observed at the AHS AREC vineyard.

Wine comments: Vidal is typically produced as a varietal wine. Like Chardonnay, Vidal is a versatile grape suited to a number of different soils and climates. Also like Chardonnay, it can be used to make a variety of wine styles from sparkling wine cuvées (base wine) to complex Burgundian-style products. With adequate fruit maturity Vidal is often whole cluster pressed to reduce phenol extraction. It has proven to be a successful blending component with high terpene varieties such as Riesling, Muscat Ottonel and Malvasia bianca. Due to Vidal's ability to "hang" in the vineyard, it has been successfully used to produce late-harvest style wines influenced by Botrytis and cryoextraction-type ice wines. Varietal descriptors include melon, pineapple, lead pencil, pears, and figs. Suitable for home grape and wine production with modest pest control programs.

Chardonel



White, interspecific hybrid

Chardonel is an interspecific hybrid that resulted from a cross between Seyval and Chardonnay made in 1953. The variety was released by the New York State Agricultural Experiment Station in Geneva in 1990. Chardonel might be best viewed as an alternative to Seyval, with several similarities to Vidal in terms of yields, vegetative growth, bunch rot resistance and cold hardiness. An early-season variety (Appendix B).

Strengths:

- High yields: Chardonel averaged close to 5 tons/acre without the overcrop tendency observed with Seyval (Table 13). Unlike Seyval, Chardonel does not require crop thinning.
- Excellent fruit and wine quality: The fruit shows a good balance of sugar and acid, at relatively low pH (Table 13). The wines produced have been excellent when mature fruit are used, with fruit aromas characteristic of both parents. Chardonel also has potential for sparkling wine due to its high acidity.
- Good cold hardiness: Chardonel sustained 26% primary bud kill in January 1994 which had no consequence on crop yield that year (Appendix D). Its cold hardiness is generally rated as better than Chardonnay but less than Seyval.
- Good bunch rot resistance: Unlike its parents, Chardonel has very low susceptibility to bunch rots due to its loose clusters (Table 13).

Weaknesses:

- Lack of commercial experience in Virginia: The performance of Chardonel has been superior to Seyval at the AHS AREC vineyard, but commercial experience in Virginia is generally lacking. Independent producers should fully explore market for Chardonel fruit before planting.
- Susceptibility to crown gall: Experience in Michigan indicated that Chardonel is susceptible to crown gall in wet sites.
- Susceptibility to phylloxera: Four of the original 15 vines of own-rooted Chardonel succumbed to phylloxera at the AHS AREC vineyard by 1998. It is strongly recommended that Chardonel be grafted onto a pest-resistant rootstock if grown in Virginia.

Suggested clones: No specific recommendations.

Suggested spacing and training: Cordon training with spur-pruning and vertical, upright shoot positioning has worked well at Winchester. We lack experience with other systems.

Wine comments: Chardonel is typically produced as a varietal wine. In Virginia, the grape can attain a relatively high soluble solids concentration, while maintaining a high acid and low

Table 13. Harvest date, fruit harvest chemistry, components of crop yield, and fruit rot severity at harvest for Chardonel, as grown at the AHS AREC vineyard in Winchester, VA.

		Fruit chemistry						
Year	Harvest date	°Brix	Titratable acidity (g/L)[v]	pH[w]	Berry wt. (g)	Cluster wt. (lb)	Crop yield (t/a)[x]	Rot severity (%)[y]
1991	28 Aug	23.1	4.5	3.27	2.1	0.28	3.9	.
1992	2 Oct	23.1	5.8	3.50	2.4	0.40	4.7	1.2
1993	14 Sept	24.5	5.2	3.33	2.3	0.37	4.9	< 1.0
1994[z]	16 Sept	23.2	7.2	3.15	2.4	0.46	5.4	< 1.0
1995	26 Sept	24.0	8.5	3.37	2.4	0.44	5.5	< 1.0
1996	7 Oct	21.9	7.5	3.43	2.6	0.32	3.0	2.7
1997	30 Oct	24.2	5.9	3.50	2.5	0.51	4.6	< 1.0
1998	3 Sept	23.2	6.5	3.36	2.3	0.43	5.0	< 1.0
Mean	19 Sept	23.4	6.4	3.36	2.4	0.40	4.6	1.3

w-z Footnotes identical to those in Table 4.

pH. Thus, it is ideally suited for the production of semi-dry to sweet wines. As a dry wine, Chardonel shows attributes of its parents, Chardonnay and Seyval, but can have high alcohol levels. Controlled skin contact is occasionally used to enhance varietal aroma and flavor intensity. Chardonel is also used as a sparkling wine base, and is suitable for home grape and wine production. Varietal descriptors include fruity, delicate.

Traminette

White, interspecific hybrid

Traminette is a hybrid which resulted from a cross between Joannes Seyve 23-416 and Gewürztraminer made in 1965. The variety was released by the New York State Agricultural Experiment Station in Geneva in 1996. Traminette was planted at the AHS AREC vineyard in 1995; thus our experience and data are limited. Traminette has, however, been commercially grown in New York State, Pennsylvania, and Michigan since the mid- to late-eighties. Traminette is distinguished by its superior wine quality with pronounced Gewürztraminer character. Traminette is at least 50% *V. vinifera*, and should therefore be grafted onto a phylloxera-tolerant rootstock. Fruit ripens mid-season (Appendix B).

Strengths:

- Good yields: Traminette grown at the AHS AREC vineyard produced the equivalent of 3.3 tons/acre in their second year and 4.2 tons/acre in their third season. Mature vineyards in the Finger Lakes Region of New York State yielded 5 to 7 tons/acre, with similar reports from Michigan.
- Excellent fruit quality: This hybrid produces fruit and wines similar to one of its parents, Gewürztraminer. Data from New York State indicate excellent balance between sugar, acidity and pH. Traminette tends to produce wines with lower pH and less bitter phenols than Gewürztraminer.
- Good cold hardiness: Data from New York indicate that Traminette is hardier than Gewürztraminer, but not as hardy as Seyval. A cold spell in New York in 1992-93 dropped the temperature to -17°F, which caused 95% primary bud kill in Riesling and only 15% in Traminette. Cold hardiness has not been evaluated in Virginia.
- Good disease resistance: Foliage and fruit are moderately resistant to powdery mildew, black rot, and Botrytis bunch rot.

Weaknesses:

- Lack of commercial experience in Virginia.
- Uncertain demand: Owing in part to the novelty of Traminette, the demand for fruit is uncertain.

Suggested clones: No specific recommendations.

Suggested spacing and training: Cordon training with spur-pruning and vertical, upright shoot positioning has worked well at Winchester. We lack experience with other systems.

Wine comments: Traminette is typically produced as a varietal wine which exhibits some aroma and flavor characteristics of Gewürztraminer, one parent. Wines are suitable to several different styles but are usually finished with some residual sweetness. Its relatively high acid and low pH help to complement its fresh fruit aromas and flavors. Limited skin contact can enhance aroma intensity but should be done with caution to avoid excessive phenol extraction, which can detract from the wine's elegance. Varietal descriptors include floral, spicy, perfumed, lavender.

Chambourcin

Red, interspecific hybrid

Chambourcin is the only red interspecific hybrid currently recommended in Virginia. Chambourcin has been used to produce varietal wines as well as blends with other red-fruited varieties, including the Cabernets. Acreage is less than 5 percent of total grape acreage. Fruit matures late-season (data not shown).

Strengths:

- Good winter cold hardiness: Comments are similar to those made for Seyval.
- Good rot resistance of fruit: Fruit bunch rots have not been particularly troublesome with Chambourcin.

Weaknesses:

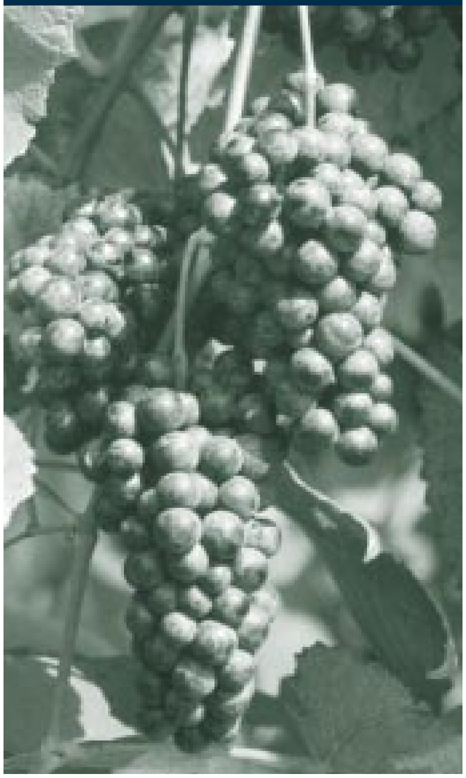
- Early budding: May be subject to spring frost due to early spring shoot development (Appendix C).
- Weak growth and poor yields: Periodic tissue sampling and observations of vine size and vine vigor are recommended to monitor the nutrient status of Chambourcin and to maintain vine size/productivity. Routine applications of nitrogen (e.g., 50 to 100 pounds of actual nitrogen per acre per year) are usually needed to maintain vigor, vine size, and productivity. May benefit from grafting to a pest-resistant rootstock to increase vine vigor and vine size.
- Uncertain long-term demand by wineries: As with any variety, be certain that a market exists for projected yields before ordering grapevines.

Suggested clones: No specific recommendations.

Suggested spacing and training: Adaptable to many non-divided training systems, including high training with downward shoot orientation. Cordon-training with spur-pruning is acceptable. Non-grafted grapevines typically spaced 6 to 8 feet apart in the row.

Wine comments: Chambourcin can be produced as a varietal wine or used in blending with other mid- to full-bodied red wines. Chambourcin produces a wine with a distinct aroma and herbaceous flavors which are more vinifera-like than most red hybrids. The fruit frequently has a high acid content, which can clash with immature tannins. Fruit can be short-vatted to produce a rosé or Beaujolais style (with or without the use of pectinolytic enzymes) or used to produce a medium-to full-bodied, fairly complex wine if adequate maturity is reached. Chambourcin is used to produce a varietal wine, as a blender with varieties such as Cabernet Sauvignon, and to produce port-style products. Varietal descriptors include raspberry, earth and clove. Cherry, plum, tar, fresh tobacco and berry-like aromas develop with aging. Suitable for home grape and wine production.

Norton



Red, V. aestivalis

Norton (syn., Cynthiana) is a *Vitis aestivalis* variety of uncertain origin; one claim is to Virginia, another is Long Island. The majority of plantings exist in Missouri and Arkansas; less than 20 acres are planted in Virginia. Norton is used for varietal wines (>74% Norton composition) and is also used as a color and flavor enhancing component of red blends. Fruit matures late-season (Appendix B).

Strengths:

- Excellent cold hardiness: Norton sustained 23% primary bud kill following -11°F exposure at the AHS AREC in Winchester, Virginia in January 1994 (Appendix D). Laboratory freeze tests of vines grown at Winchester predicted that more than 50% primary bud kill could be expected at or below mid-winter temperatures of -20°F. Norton is therefore one of the most cold hardy varieties that we can recommend for Virginia.
- Excellent fruit and wine quality: Norton produces excellent wines characterized by deep pigmentation, good structure, and vinifera-like flavors that integrate well as the wines age.
- Disease resistance: Vines are relatively tolerant of common fungal pathogens (Table 1). Therefore, Norton can be economically protected using about one-quarter the number of sprays used with vinifera varieties.

Weaknesses:

- Low yields: Crop yields of Norton could be frustratingly low (less than 1 ton/acre). One of the reasons is small clusters and small berries. Yields of 4 to 6 tons/acre have, however, been commercially obtained by using high training, preferably Geneva Double Curtain.
- High acid and pH: At maturity, Norton fruit can have both high titratable acidity (>8 g/L) and high pH (>3.7), which may require blending, amelioration, or deacidification to produce a balanced wine. Fruit acidity can be reduced by using high training systems and selective leaf removal from fruit zones to promote fruit exposure to sunshine.
- Susceptible to bird depredation: Like other small-berried, darkly pigmented grapes, Norton fruit is attractive to birds.
- Early bud break: Early spring budding (Appendix C) increases spring frost hazard. The threat of spring frost can be minimized by prudent site selection.
- Limited markets: Relatively few Virginia wineries currently purchase Norton grapes, but interest among others is increasing.

Suggested clones: No specific recommendations.

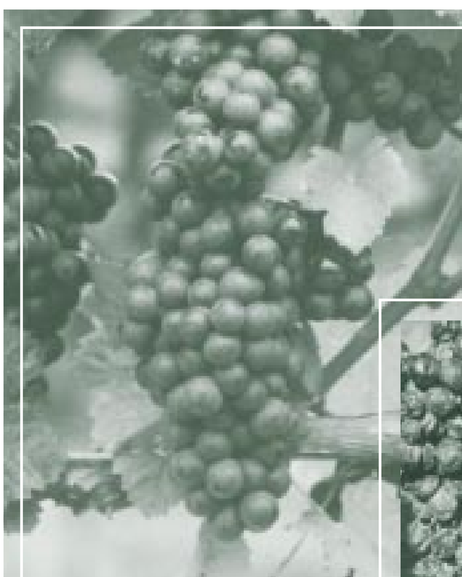
Suggested spacing and training: Like most American species, Norton shoots have a trailing or procumbent growth habit which facilitate downward shoot positioning. High training, such as Hudson River Umbrella and Geneva Double Curtain, is therefore recommended. Growth is initially weak, but performance of Norton in the Piedmont and at the AHS AREC in Winchester, Virginia suggests that Geneva Double Curtain training, with cordon training and long-spur pruning, is warranted to optimize yields and quality.

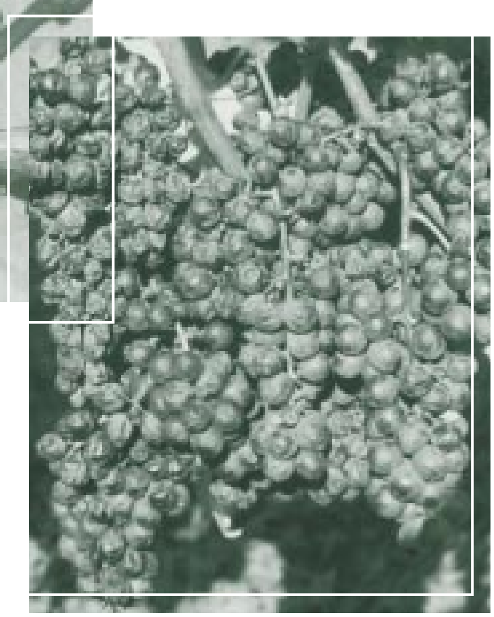
Wine comments: Unlike other native American varieties, Norton wines do not have the “foxy” aroma or flavor characteristic of labrusca wines. With age, Norton wines acquire aroma and flavor characteristics common to Cabernet Sauvignon, Syrah and Zinfandel. Typically, Norton is cold soaked and long-vatted (sometimes with extended maceration) to produce a wine which is complex and full-bodied with a firm tannic structure, red color and long aging potential. This small-berried variety has a high phenol content and produces a wine of very high color intensity due, in part, to the large surface to volume ratio (see Appendix E). As with most red varieties, tannin maturity in the fruit is highly important. The grape is characterized by having a low tartaric to malic ratio (average 0.5) and a high titratable acidity (0.8 g/L) which may require deacidification. Structural problems arise in the wine if the acid concentration is too high and are compounded by the presence of a high concentration of immature phenols. With adequate fruit maturity the wine may benefit from pre-fermentation tannin additions to improve its structure. Because of the small berry size, cap management is difficult and care must be used to avoid extraction of excessive, harsh phenols, including seed tannins. Like many varieties, Norton produces a better-structured, more complex product if blended. In Virginia, it is successfully blended with Cabernet Franc, Cabernet Sauvignon, Mourvèdre, Touriga and Chambourcin. The grape has also been successfully used to produce traditional port-style wines, which take advantage of the high acid and anthocyanin concentrations. Varietal descriptors include raspberry, back pepper, mushroom, leather, spicy, jammy, earthy, dusty, nutmeg, tobacco and chocolate. Suitable for home grape and wine production, but may require netting to exclude birds.

Varieties not generally recommended, but worthy of consideration for specific uses or only in exceptional sites

- Merlot
- Sauvignon blanc
- Touriga nacionale
- Fer Servadou
- Tannat

Fer Servadou





Tannat

The following varieties are not generally recommended due to lack of research data or commercial production in diverse areas of Virginia. Uncertain winery demand, extreme susceptibility to winter cold injury, or high susceptibility to bunch rots, are other risk factors. On the other hand, some of the following varieties (e.g., Merlot) may be well suited to areas of the state that are free of winter injury concerns. Others, such as Touriga nacionale, have performed well in commercial vineyards, but long-term trials in diverse regions of the state are lacking.

Merlot

Merlot is quite sensitive to cold injury and crown gall and thus can only be recommended in sites where experience has demonstrated that winter injury is not a serious threat. Merlot fruit is also highly susceptible to bunch rots. Rot development often necessitates early harvest and less than optimal fruit quality. In good sites with relatively dry harvest seasons, Merlot grape and wine quality can be exceptional. Merlot, the grape of Pommerol, can produce a premium Virginia red wine which is supple and fruity. Skins of Merlot berries are thinner than those of Cabernet Sauvignon and provide less extract and tannin. "Weedy" wine tones may override the desirable varietal aromas/flavors, complexity and quality. Like most red varieties, optimum vineyard management (light exposure of the fruit) and adequate maturity are essential in minimizing herbal or vegetal "notes." The wine is usually produced by dejuicing prior to dryness. Some produce Merlot as a 100% varietal. In most seasons the wine is better suited as a blend component where its supple tannins can be enhanced by the aroma/flavor profile of other varieties. Merlot's most common blending partner, Cabernet Sauvignon, adds rich berry-like aroma and flavors, structure and backbone. Varietal descriptors include herbaceous, leafy, perfumed, cherry, raspberry, fruit-cake, black currant. Merlot clone evaluations were begun at the AHS AREC in 1998.

Sauvignon blanc

Highly susceptible to Botrytis and other bunch rots; vines have a long vegetative cycle that can lead to poor wood maturation and increased winter injury at sites with less than 180 (±) frost-free days. Maturity evaluations of Sauvignon blanc, like others, should be based on aroma and flavor evaluation in order to obtain stylistic goals. The wine typically has 'grassy'-type aromas and flavors which may reduce overall complexity. Ripe fruit and sun exposure help to minimize the concentration of the compounds responsible for the assertive, herbal character while maximizing "fruit" character. The variety has a tendency to quickly increase in sugar content which corresponds to significant changes in aromas and flavors. Care must be used to avoid over maturity which can result in excessive wine alcohol. The variety is usually whole cluster pressed or crushed and pressed with segregation of press fractions. While pre-fermentation skin contact increases varietal intensity, it may also excessively increase the phenolic "load." The grape is frequently fermented in stainless steel, neutral barrels or both. Varietal descriptors include fruity (citrus, peach, apricot), vegetative (bell peppers, asparagus), and green olive.

Touriga nacionale

This small berried, mid-season red variety, traditionally used for port production, is highly tannic and colored. While not extensively planted, Touriga seems to perform well in Virginia. It seldom reaches more than 22 °Brix, yet at that sugar concentration can have supple tannins. The wine is occasionally produced by 'bleeding' (about 10% liquid reduction) prior to fermentation and is frequently fermented to dryness on the skins or dejuiced slightly before dryness. Touriga usually

Table 14. Harvest date, fruit harvest chemistry, components of crop yield, and fruit rot severity at harvest for Fer, as grown at the AHS AREC vineyard in Winchester, VA.

		Fruit chemistry						
Year	Harvest date	°Brix	Titratable acidity (g/L)[v]	pH[w]	Berry wt. (g)	Cluster wt. (lb)	Crop yield (t/a)[x]	Rot severity (%)[y]
1992	21 Oct	21.9	5.1	3.42	1.9	0.46	4.4	< 1.0
1993	7 Oct	22.1	5.6	3.59	2.0	0.37	2.8	< 1.0
1994[z]	18 Oct	.	.	.	.	0.32	0.6	.
1995	23 Oct	21.8	5.1	4.00	1.8	0.37	3.8	< 1.0
1996	31 Oct	18.9	8.1	3.73	2.0	0.24	1.6	<1.0
1997	20 Oct	22.3	5.1	3.51	2.2	0.42	5.1	0.0
1998	29 Sept	21.5	4.5	4.00	1.9	0.32	3.7	< 1.0
Mean	11 Oct	21.4	5.6	3.71	2.0	0.36	3.5	0.8

v-z Footnotes identical to those in Table 4.

requires chaptalization to produce the 13-13.5 % alcohol (v/v) required to help balance the wine phenols and acidity. It is desirable to add a source of assimilable nitrogen during the fermentation due to the variety's tendency to produce hydrogen sulfide and mercaptans. In Virginia, Touriga nacionale is blended with Cabernet Sauvignon, Petit Verdot and others to improve the mid-palate structure. Varietal descriptors include blackberry, tar, anise, cassis, and coffee.

Fer Servadou

Red, *V. vinifera*. Evaluated at AHS AREC in Winchester, VA. Fer has traditionally been used in blended wines of southwest France where it is sometimes called Pinenc. It is allowed in wines as far north as Bergerac, but today it is most important to the red wines of the Aveyron. Wines made from fruit collected at Winchester were well colored, concentrated, with a pleasant aroma of smoky, berry fruit. Fruit maturity is late-season (Appendix B).

Strengths:

- Late bud break: Average bud break of Fer has averaged about 7 days later than Chardonnay (Appendix C).
- Good fruit quality: Fruit quality at harvest has been good, with slightly higher pH and acidity than that of the Cabernet Sauvignon clones (Table 14).

Weaknesses:

- Susceptible to winter cold injury: Laboratory freeze tests of vines grown at Winchester predicted that more than 50% primary bud kill could be expected at or below mid-winter temperatures of -7°F. A temperature of -11°F in January 1994 resulted in 99% primary bud kill, and more than 50% trunk injury (Appendix D). For this reason, Fer is recommended only for excellent sites.
- High acid and pH: Similar comments as for Petit Verdot. Fer is viewed as a blending variety to Bordeaux style wines.
- Uncertain demand: Not recommended for independent grape producers due to uncertain winery demand.

Wine comments: Fer produces a balanced, well colored wine, with slightly greater anthocyanin concentration than Cabernet Sauvignon (Appendix E). With adequate tannin maturity the pH of the fruit can be high. The grape can produce a wine of medium body with firm yet sweet, supple tannins, lively acidity and intense varietal aromas and flavors. In southwestern France it is used as a blender with Tannat and other varieties and should also be used to produce a blended wine in Virginia. Varietal descriptors include black currant and raspberry.

Tannat

Red, *V. vinifera*. Evaluated at AHS AREC in Winchester, VA. Popular in southern France. Young wines are deeply colored, perfumed and tannic. Fruit matures mid-season (Appendix B).

Strengths:

- Late bud break: Tannat averages 13 days later than Chardonnay (Appendix C).
- High yields: The average is over 5 tons/acre, and in 1997 the yield was 6.7 tons/acre (Table 15). According to crop load data, it seems that this variety could regularly produce about 6 tons/acre without compromising the vine balance. Tannat had the greatest number of berries per cluster (average ~ 153) among 25 varieties and clones grown at the AHS AREC vineyard.
- Excellent fruit quality: Low potential for fruit rots, and high sugar accumulator. Total acidity remains relatively high, and can be excessive in cool years (Table 15). Good blending potential.

Table 15. Harvest date, fruit harvest chemistry, components of crop yield, and fruit rot severity at harvest for Tannat, as grown at the AHS AREC vineyard in Winchester, VA.

		Fruit chemistry						
Year	Harvest date	°Brix	Titratable acidity (g/L)[v]	pH[w]	Berry wt. (g)	Cluster wt. (lb)	Crop yield (t/a)[x]	Rot severity (%)[y]
1991	26 Sept	20.2	3.9	3.72	1.6	0.32	6.1	.
1992	15 Oct	22.1	9.6	3.38	1.8	0.54	4.4	2.7
1993	7 Oct	20.7	9.1	3.35	1.7	0.69	8.8	< 1.0
1994[z]	18 Oct	.	.	.	.	0.28	0.9	.
1995	13 Oct	25.5	6.3	3.91	1.9	0.68	3.8	<1.0
1996	15Oct	21.1	12.2	3.55	2.0	0.61	3.0	3.1
1997	15 Oct	26.4	9.0	3.66	1.8	0.71	6.7	<1.0
1998	18 Sept	23.8	8.3	3.72	1.9	0.81	7.5	0.0
Mean	8 Oct	22.8	8.3	3.61	1.8	0.62	5.2	1.5

v-z Footnotes identical to those in Table 4.

Weaknesses:

- Susceptible to winter cold injury: Laboratory freeze tests of vines grown at Winchester predicted that more than 50% primary bud kill could be expected at or below mid-winter temperatures of -7°F. A temperature of -11°F in January 1994 resulted in 100% primary bud kill, and almost complete trunk loss (Appendix D). For this reason, Tannat is recommended only for excellent sites.
- Uncertain demand: Not recommended for independent grape producers due to uncertain demand.

Wine comments: Tannat is a mid-season black grape used as a blend component in red and rosé wines. At optimum tannin maturity the variety is 23-24 °Brix and 7 to 10 g/L acid with a relatively low pH range of 3.1 to 3.3. Fruit is tannic and deeply colored and helps to provide structure, color and longevity to red wines. Because of the high tannin load (see Appendix E) the grape is usually dejuiced prior to dryness to avoid making a wine which could be described as too rustic although tannin may be added during fermentation to improve the overall structure of the wine. Because of the tannin structure the wine is suitable for storage in a wide range of cooperage, from new to seasoned wood. Wines are highly colored, with rich, firm tannins and a high alcohol used for blending. Varietal descriptors include black cherry and plum; not a particularly elegant bouquet.

Winegrape Varieties Not Recommended In Virginia

Gewürztraminer

Nebbiolo

Riesling

Sangiovese

Seyval

Pinot noir

The following varieties have seen some cultivation under a wide range of Virginia growing conditions. In some years, the yields and quality can be outstanding. However, when the experiences of many are considered, the good years are the exception.

Gewürztraminer

Gewürztraminer fruit is very prone to rot, generally before the fruit is ripe. Varietal fruit character can be lacking in hot seasons and fruit pigments develop unevenly in shaded canopies.

Nebbiolo

Poor yields and poor fruit quality in tests at AHS AREC, Winchester, Virginia; susceptible to winter cold injury.

Riesling

Despite being the third most abundant variety grown in Virginia in 1998, we can not offer a strong recommendation to plant Riesling. While Riesling is relatively cold-hardy, the variety suffers from a number of defects. Fruit tends to split and rot before optimally ripe. Typical Riesling flavors and aromas are not consistently obtained in Virginia's hot climate. Riesling yields are often poor, a result of occasionally high levels of primary bud necrosis (Wolf and Warren, 1995).

Sangiovese

A tendency to overcrop can lead to thin, poorly pigmented wines. Vines are exceptionally cold-tender.

Seyval

A tendency to overcrop can lead to thin wines and reduced vine vigor. Fruit is highly susceptible to Botrytis and other bunch rots due to compact cluster. Crop value may not justify cost of production for independent grape growers. Despite these negatives, Seyval is one of the most abundant hybrid varieties currently grown in Virginia. Wine quality can be good to excellent if vines are well managed.

Pinot noir

More work is needed in Virginia to evaluate some of the numerous Pinot noir clones. The principal limitation seen with Pinot noir currently being grown in Virginia is the tendency for fruit to rot before it's ripe. While there are numerous Pinot noir clones, most have very compact clusters which increases the likelihood of bunch rots. Research at the New York State Agricultural Experiment Station in Geneva, NY has shown that the "Clevener Mariafeld" clone of Pinot noir offered the most consistent resistance to bunch rots (Pool *et al.*, 1995). Vintners interested in sparkling wine production might also have interest in Pinot noir. Fruit destined for sparkling wine production is harvested at lower sugar and higher acid levels than is fruit used for still wine production. That earlier harvest could avoid much of the potential rot problems seen with Pinot noir.

Other interspecific hybrids

Chancellor, Foch, Baco noir, DeChaunac, Aurore, Villard blanc, Villard noir, Rayon d'Or, Chelois, and Rougeon are grown in commercial quantities in several Virginia vineyards. Viticulturally, some of these varieties perform quite well and are relatively easy to manage. Wines can be acceptable, occasionally good, but rarely memorable. Some can be recommended for home wine production. Relatively few wineries are currently purchasing these grapes and demand is not expected to increase.

Native American and muscadine grapes

With the exception of Norton (*V. aestivalis*) and a small amount of Niagara (V. *labrusca*) grapes, none of the native American grape varieties (e.g., Concord) significantly figure in Virginia winemaking. Thus, these grapes are generally not recommended for commercial production in Virginia.

Table Grape Varieties

Himrod

Interlaken

Lakemont

Reliance

Vanesa

Einset

Glenora

Mars

Concord

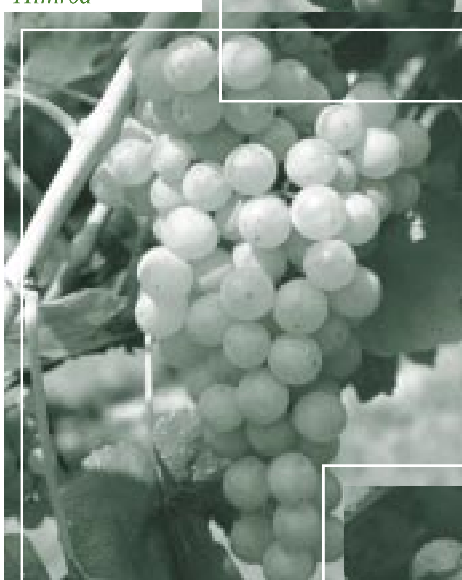
Niagara

Seneca

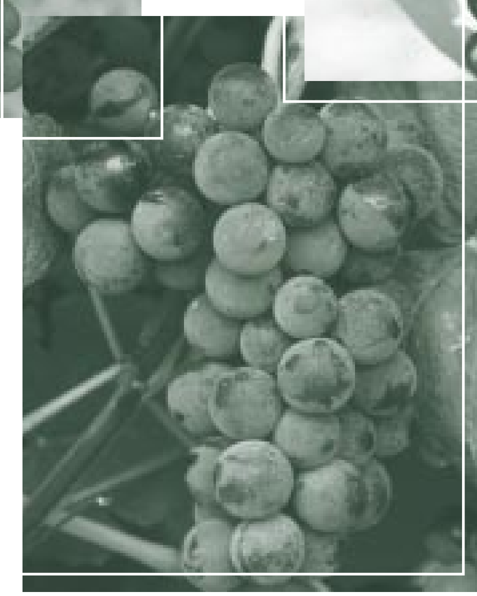
Steuben

Vanessa

Himrod



Glenora



Mars

Table grapes represent less than 4 percent of the total Virginia grape acreage. Most of the present acreage is comprised of *seeded* table grapes such as 'Concord', 'Niagara', and 'Fredonia'. Interest in seedless table grape varieties has increased in recent years, particularly in light of consumer surveys, which document preference for seedlessness. Thus, the following discussion will first consider seedless varieties, followed by recommendations for a few seeded varieties.

Markets: As with winegrape varieties, the market for table grapes should be examined prior to planting. Owing to the small volume of crop produced by most Virginia table grape operations, most crops are direct-marketed, as opposed to being sold via wholesale channels. Direct markets include roadside stands, pick-your-own, farm markets, and grocery stores. Profit potentials are not as great with table grape production as they are for wine grapes for the following reasons:

- Vineyard establishment and operational costs are roughly comparable for seedless table grapes and wine grapes
- Table grapes have a short shelf-life
- The demand for "Virginia-grown" wine grapes is not paralleled by a comparable demand for Virginia-grown table grapes
- Consumers place a premium on fruit attractiveness. Spray residues, unripe berries, insect damage, and other fruit blemishes reduce the value of table grapes
- Birds, raccoons, opossums, deer, and other wildlife are particularly attracted to seedless table grapes.

Recommended Seedless Table Grape Varieties

The following seedless table grape varieties have demonstrated commercial potential in Virginia. Note that with all varieties, one or more potential detracting qualities are described. The occurrence of such defects varies from site to site and year to year and may or may not be evident under your own growing conditions.

Fruit color: Grape berry color is customarily expressed as white, red, blue, or black. "White" fruit varies from pale green to amber, depending on variety and degree of ripeness. Similarly, "red"- fruit varieties can vary from muddy green to deep red.

"Seedlessness": Noticeable seeds can be found in so-called "seedless" grapes. Seeds can be soft and barely noticeable or they can have hard seed coats.

Himrod: Himrod, Interlaken, Lakemont, and Romulus are "sister" varieties resulting from a cross between Ontario and Thompson Seedless made at Geneva, New York, in 1928. Ontario is an American-type grape and Thompson Seedless is a vinifera. Himrod was named in 1952. It is white-fruited and ripens early, relative to other seedless grapes (late-July in northeast Virginia). Fruit quality is excellent and berry size can be increased with cluster thinning, gibberellic acid and/or cane girdling. Berry pedicels, the small stems that attach individual berries to the cluster, tend to be brittle, and berry shelling can result from excessive cluster handling or prolonged storage.

Interlaken: Interlaken was named in 1947. Fruit is white and ripens as early, if not earlier, than Himrod. Fruit quality is excellent and responds to berry size enhancement practices. Interlaken vines are moderately susceptible to winter cold injury and should not be planted in sites prone to severe winter temperatures.

Lakemont: A white variety that ripens about one week after Himrod. Fruit quality is good to excellent and fruit reportedly stores well. A potential problem with Lakemont is the development of uneven berry size on a given cluster and a smaller berry, on average, than other table grapes.

Reliance: Reliance is a red-fruited variety released from the Arkansas breeding program in 1983. Fruit ripens about the same time as Himrod and has an excellent labrusca-type flavor. Fruit aroma and flavor can become overbearing if fruit is allowed to overripen. Many feel that Reliance is perhaps the finest flavored eastern table grape currently named. The vines are quite vigorous, exceptionally cold hardy and can produce extremely large crops if properly managed. Berry cracking has been a problem in cases where heavy or prolonged rains occur around harvest. Noticeable seed traces are observed in some years. Experience with Reliance and other red-fruited varieties in Virginia indicates that shaded (as by canopy foliage) clusters do not develop berry color as well as exposed clusters. Vine training and other aspects of canopy management should take this observation into consideration.

Vanessa: Vanessa is a red-fruited variety introduced in 1985 at the Vineland Research Station in Ontario, Canada. Fruit matures about a week after Himrod. Berries are attractive, very firm, and have good flavor. Fruit clusters are rather small and vines in Virginia have tended to be of low vigor. Trials with grafted vines are in progress. Some berry splitting has been observed in wet years. Seed traces are noticeable in some years.

Einset: Einset is a red-fruited variety named at Geneva, New York, in 1985. The fruit is resistant to cracking and ripens at approximately the same time as Himrod. Fruit quality is excellent. Flavor is Labrusca-like but not as pronounced as that of Reliance. Clusters reportedly respond well to cultural improvement practices and store well. We have limited commercial experience with Einset in Virginia.

Glenora: Glenora is a black-fruited variety released from Geneva, New York, in 1977. Berries and clusters are relatively small, but respond to girdling and gibberellic acid. Fruit flavor can be excellent. A potential defect with Glenora is inconsistent fruit quality: in some years the fruit has very little flavor. Another occasional problem with Glenora has been the occurrence of dehydrated berries on the cluster, which might be due to berry cracking and subsequent drying.

Mars: Mars is a blue-black grape released from the Arkansas breeding program in 1985. Flavor is labrusca-like, similar to the pronounced labrusca character of Concord. Clusters tend to be smaller than average. Vines are vigorous and relatively resistant to common diseases, making this variety attractive to home grape producers. Commercial trials with Mars in Virginia are lacking.

Seedless Table Grape Varieties Not Recommended In Virginia

The following seedless table grapes are considered unsuitable for commercial planting due to one or more defects. Again, these recommendations attempt to cover a broad geographic area. Defects that are observed in some sites might not be a major problem at your site. Thus, if planting space exists, you might wish to plant a few of these vines on a trial basis. Don't make major commitments, however, until vines are five or more years old. Weaknesses in character may not appear until vines mature.

Romulus: Romulus is another white-fruited "sister" of Himrod, Lakemont, and Interlaken. Fruit ripens up to two weeks after Himrod. Primary objections to Romulus are small berry size and mediocre fruit quality.

Suffolk Red: Suffolk Red can have an excellent flavor but the chief complaints are poor fruit coloration in some years and poorly filled clusters.

Remaily: Remaily clusters produce many "shot" berries, and the flavor of this white-fruited variety is mediocre under Virginia growing conditions. Berries are also subject to abrasion and sunburning, which detract from appearance.

Canadice: Canadice fruit clusters tend to be overly compact, which leads to berry cracking and subsequent rot. Furthermore, the red pigment of berries does not develop consistently in all seasons.

Venus: Venus is an extremely high-yielding, blue-black fruited variety from the Arkansas breeding program. Vines are quite hardy and vigorous. Venus berries tend to be tough-skinned, retain noticeable seed traces, and have only mediocre quality. Thus, although the fruit is attractive and produced in large quantities, it generates few repeat customers.

Vinifera table grapes: As a group, the vinifera table grapes such as Flame Seedless and Thompson Seedless have not exhibited sufficient cold hardiness to warrant commercial planting in Virginia. Furthermore, fruit is prone to rot.

Seeded Table Grapes

Several seeded table grapes enjoy commercial acceptance in Virginia and many are well suited for home wine and table grape production. Some are eaten fresh while others are processed for juice and jellies. Seeds are a minor concern in the latter case. Most of these varieties have "slip-skin" fruit in which the skins do not adhere to the flesh. The following seeded table grapes can be recommended for nostalgic (e.g., Concord), or other reasons.

Concord: Concord is a blue-black variety which is probably the most commonly grown "back-yard" grape in the Eastern U.S. and the dominant table grape in Virginia. Concord vines are hardy, vigorous, productive and perform well in somewhat acidic soils. Concord's strength owes principally to consumer recognition. The primary defect noticed with Concord in Virginia is uneven fruit coloration. This can be due to overcropping, canopy shade, and heat; the warmer areas of the state have more problems with uneven fruit color development than do the cooler regions. In response to uneven berry ripening, the University of Arkansas released the variety Sunbelt, reported to have more uniform color development in hot grape regions. In other respects, Sunbelt would be very similar to Concord.

Niagara: Niagara is a white-fruited variety used for fresh consumption, jellies, and even wine. Vines are vigorous and hardy and adaptable to a wide range of soil conditions. Like many of the American-type varieties, the Niagara fruit flavor is strongly labrusca in character.

Seneca: Seneca bears white-fruited berries that are firm and of excellent flavor. Vines are vigorous and produce large crops if properly managed. Fruit ripens early, around the first week of September in northern Virginia.

Steuben: Fruit is bluish-black and possesses a distinctive spicy flavor. Steuben vines are vigorous and productive. Fruit coloration can be non-uniform if vines are overcropped.

Many other seeded table grapes have been tried in limited quantities in Virginia. Some have limited commercial potential, but that potential should be initially explored with small test plantings.

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General Information

Foundation Plant Materials Service, University of California, One Shields Ave., Davis, CA 95616-8600 (530-752-3590). Grape varieties, clones and rootstock plant material and information.

Appendices

Appendix A.

Wine grape varieties, clones, or selections evaluated at Winchester AREC vineyard. Clonal designations, where known, are shown as numbers that follow the varietal name.

Variety/clone or selection	Source[z]	Principal reason(s) for not generally recommending in Virginia
Cabernet Sauvignon #6	FPMS	
Cabernet Sauvignon #7	FPMS	
Charbono #3	FPMS	Mediocre wine quality; excessive crop production
Chardonnay #4	FPMS	
Chardonnay #16	FPMS	Insufficient crop production; winter-tender
Chardonel	NYS FTC	
Fer Servadou	NYS FTC	
Gruner Veltliner #1	FPMS	Susceptible to fruit rots; otherwise, has potential
Limberger	AG	Mediocre fruit quality
Mourvèdre	SG	
Malvasia bianca #3	FPMS	
Muscat Ottonel #1	FPMS	
Nebbiolo #1	FPMS	Erratic yields; winter-tender; mediocre fruit quality
NY 62.122.1	NYSAES	Insufficient data
Norton	FKN	
Petit Manseng	NYSAES	Very high acidity; otherwise, has potential
Petit Verdot	NYSAES	
Refosco	NYSAES	Mediocre fruit quality
Sangiovese #2 (grosso)	FPMS	Winter-tender; mediocre fruit quality
Syrah #6	FPMS	Winter-tender; erratic fruit quality
Tannat #1	FPMS	
Traminette	NYSAES	
Valdepeñas	NYSAES	Winter-tender; otherwise, has potential
Vidal	NYS FTC	
Viognier	NYSAES	

z Source abbreviations: AG = Agriculture Canada, Summerland, BC; FKN = Forrest Keeling Nurseries, Arkansas; FPMS = Foundation Plant Materials Service, Davis, CA; NYSAES = New York State Agricultural Experiment Station, Geneva, NY; NYS FTC = New York State Fruit Testing Cooperative, Geneva, NY (disbanded); SG = Sonoma Grapevines, Fulton, CA.

Appendix B.

Phenological data and relative time of fruit maturity for wine grape varieties evaluated at the AHS AREC vineyard in Winchester, Virginia.

Relative time of crop maturity	Variety	Number of days from: Bud break to bloom	Bloom to harvest	Bud break to harvest
Early-season	Muscat Ottonel	48	96	144
	Malvasia bianca	50	96	146
	Viognier	46	108	154
	Chardonel	54	103	157
Mid-season	Gruner Veltliner	50	111	161
	Chardonnay #4*	51	112	163
	Limberger	50	114	164
	Nebbiolo	51	113	164
	NY 62.122.1	53	112	165
	Traminette	51	114	165
	Tannat	53	114	167
Late-season	Valdepeñas	50	120	170
	Fer Servadou	45	127	172
	Cabernet Sauvignon #7	49	124	173
	Cabernet Sauvignon #6	50	124	174
	Vidal	49	126	175
	Petit Verdot	47	130	177
	Mourvèdre	48	129	177
	Syrah	52	126	178
	Norton	52	129	181
	Refosco	49	132	181
	Petit Manseng	49	133	182
	Sangiovese	49	133	182
	Charbono	55	128	183

* By way of comparison, average date of bud break, bloom and harvest of Chardonnay at Winchester, VA was 21 April, 9 June, and 25 September, respectively.

Appendix C.

Relative time to 75% bud break for common and recommended varieties. Data for varieties in normal text represent the average for years 1992-1998. Data for varieties in italics were obtained as a composite from commercial sources. Time of bud break is expressed as days after Chardonnay clone #4, which is arbitrarily set to day "0".

Days after Chardonnay			
0	Chardonnay	7	Fer, Malvasia bianca, Traminette
1	*Cabernet franc*, Merlot	8	Riesling, *Sauvignon blanc*
3	*Chambourcin*, Viognier	9	Vidal
4	Norton	10	Cabernet Sauvignon
5	Chardonel	13	Tannat
6	Seyval, Petit Verdot, Muscat Ottonel	16	Mourvèdre

Appendix D.

Comparison of primary bud mortality, incidence of trunk injury, and crop yield response of 22 wine grape varieties and clones following -11°F exposure on 19 January 1994.

Variety	Percent primary bud kill	Extent of trunk damage[x]	Crop yield/vine Average '91-'93	Crop yield/vine 1994	Percent yield change
Chardonnay #4	100	0/12	21.6	1.4	-94
Chardonnay #16	100	15/15	5.9	0.0	-100
Charbono	100	7/15	27.6	3.1	-89
Viognier	100	2/13	6.1[y]	11.6	+90
Sangiovese	100	13/15	28.7	1.0	-97
Tannat	100	9/10	24.8	0.0	-100
Valdepeñas	100	4/15	16.6	2.8	-83
Fer	99	8/15	10.6[y]	2.3	-78
Mourvèdre	97	-	z	5.9	z
Nebbiolo	96	2/15	12.6	3.5	-72
Refosco	95	0/13	17.2	19.0	+10
Petit Verdot	95	1/12	20.5[y]	13.8	-33
Malvasia bianca	95	2/14	20.5	4.0	-80
Gruner Veltliner	93	0/14	24.2	11.1	-54
Cab. Sauvignon #7	90	0/15	18.7	6.7	-64
Limberger	84	0/15	24.7	11.0	-55
Cab. Sauvignon #6	76	2/15	10.7	7.0	-35
Muscat Ottonel	74	0/15	13.4	7.7	-43
Vidal	60	0/15	18.9	26.2	+39
Petit Manseng	54	1/12	11.0[y]	9.0	-18
Chardonel	26	0/14	16.8	20.9	+24
Norton	23	0/15	2.3[y]	3.8	+65

x Trunk damage shown as number of visibly affected vines out of total present for that variety. Damage judged at end of 1994 growing season as poor shoot development or lack of shoots on affected cordons or trunks.
y Figures based only on 1993 data.
z 1994 was first expected "full" crop.

Appendix E

Analysis of intensity, hue, total phenols, and anthocyanin concentration of varietal red wines produced at the enology-grape chemistry laboratory, Virginia Tech, Blacksburg, VA. Analytic procedures as described by Zoeklein *et al*. (1995).

Year, variety, production qualification	Intensity (A420nm + A520nm)	Hue (A420nm/520nm)	Total phenols (AU)[z]	Total anthocynanins (mg/L)
92 Cabernet Sauvignon #6	10.24	0.80	44	627
93 Cabernet Sauvignon #6	7.52	0.83	33	377
93 Cabernet Sauvignon #6\CS	8.15	0.80	34	431
93 Cabernet Sauvignon #6\CS-EM	8.01	0.97	30	264
94 Cabernet Sauvignon #6\CS	9.56	0.81	36	381
94 Cabernet Sauvignon #6	10.52	0.78	41	443
92 Cabernet Sauvignon #7	9.84	0.84	37	462
93 Cabernet Sauvignon #7	7.64	0.83	28	344
93 Cabernet Sauvignon #7\CS	7.89	0.79	27	397
94 Cabernet Sauvignon #7	8.88	0.82	33	330
94 Cabernet Sauvignon #7\NTL	8.20	0.69	29	279
92 Fer Servadau	9.72	0.66	45	669
93 Fer Servadau\NTL	6.25	0.66	23	261
93 Fer Servadau	6.07	0.72	26	323
93 Fer Servadau\EM	6.47	0.80	28	265
94 Mourvèdre	8.28	0.75	30	314
92 Norton\EM	37.74	0.86	156	2542
93 Norton	18.34	1.47	90	1457
94 Norton	20.50	0.68	99	2068
92 Petit Verdot	9.84	0.75	42	549
93 Petit Verdot	8.95	0.75	38	422
93 Petit Verdot\EM	8.84	0.79	37	326
94 Petit Verdot\CS	15.32	0.71	49	450
94 Petit Verdot	14.36	0.74	43	385
94 Petit Verdot\NTL	13.32	0.76	39	192
92 Tannat	13.72	0.64	56	625
93 Tannat\NTL	5.59	0.77	26	346
93 Tannat	4.96	0.90	31	552
93 Tannat\EM	6.48	0.84	37	521

z Estimation of the concentration of total phenols expressed as absorption units (AU).

Key: EM = Extended Maceration; NTL = Native Fermentation; CS = Cold Soak.

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