Characteristics of the Cold-Climate Winegrape Industry in Vermont, U.S.A

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ABSTRACT

Vermont and other cold regions of the U.S. which experience winter temperatures below -20°C produced virtually no winegrapes before the mid-1990s. Cultivar and planting system adoption have changed rapidly in the past two decades as cultivars with increased cold hardiness and wine quality potential have become available. In the mid-1990s, the first commercial vineyards were established in the State of Vermont, and consisted of French hybrid and 'hardy' vinifera as well as cold-hardy releases from public and private breeding programs. Training systems included mid wire cordon and Geneva double curtain. Private and public breeding programs located primarily in the upper midwestern U.S. released cold-hardy winegrape cultivars in the late 1990s, continuing releases into the 21st century, resulting in increased vineyard establishment. 'Frontenac' and ''La Crescent' were the first of these cultivars to be planted in any quantity in Vermont, followed by 'Marquette'. Training systems adopted for newer cold-hardy cultivars include predominantly high wire cordon, with mid wire cordon and Geneva Double Curtain used to a lesser degree. Continued releases of new cold-hardy cultivars having greater potential for quality wine and trials of advanced selections have facilitated increased vineyard plantings and replanting of older, less desirable cultivars.

Keywords: *Vitis spp.,* value-added crop, economic impact, cultivar adoption, training systems

INTRODUCTION

Winegrape production in Vermont has expanded from virtually no vineyards prior to the 1990s to a commercial industry which exists today Traditional grape production regions worldwide typically fall between latitudes of 30° to 50°. However, very diverse climates exist within that zone that may be more or less suitable for winegrape production. The majority of wine grapes grown worldwide are *Vitis vinifera* cultivars, which evolved in dry, hot Mediterranean and Central Asian climates (Creasy and Creasy, 2009). However, the production of *V. vinifera* grapes in cool or cold and humid climates is limited by the cold hardiness and disease susceptibility of the vine. Some of the 'French Hybrids' developed in response to devastating phylloxera infestation in France and other parts of Europe have been used in cool climate regions in the U.S., but many are not hardy enough to withstand severe winters experienced in many northern parts of the country (Cahoon, 1996). There are several species of grape which originated in North America, such as *V. labrusca*, *V. riparia, V. rupestris*, and *V. aestivalis* which have greater disease resistance and cold hardiness compared to *V. vinifera*, but are often considered to have poor potential for quality winemaking. The commercial release of several cold-hardy hybrid winegrapes from the University of Minnesota (UMN) and Elmer Swenson (located in neighboring Wisconsin) breeding programs at the end of the 20th century allowed for the expansion of the winegrape industry to cold regions in North America which either had no

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substantial grape production previously or where high risk of cold damage with older hybrid cultivars limited increasing scales of production (Hemstad and Luby, 2000; Luby, 1991; Swenson, 1985). The recent expansion of viticulture to non-traditional regions which experience extreme cold, heat, humidity, and pest pressures that limit *V. vinifera* production was highlighted at a recent ISHS Symposium on Grape and Wine Production in Diverse Regions (Read, 2016).

EXPANSION OF WINEGRAPE PRODUCTION TO NORTHERN U.S. STATES

As small-scale and beginning winegrape growers in the region developed more experience with the crop, growth of the wine industry in cold-climate U.S. states was facilitated and evaluated by the Northern Grapes Project (Martinson, et al., 2016). This project supports a transdisciplinary group of collaborators from Universities in 12 states in the midwestern and northeastern U.S. Research and outreach associated with the project have included: economic analysis of wine and grape production; cultivar assessment; retail marketing and tasting room management; vine management and training trials; disease susceptibility and management; and evaluation of techniques to optimize wine quality from cold-hardy cultivars (Martinson and Particka, 2013). The focus of this project has been on the evaluation of viticultural and enological practices in cold climate regions in USDA plant hardiness zones 5b (minimum winter temperature below -26.1°C) and colder.

Winegrape industries and characteristics of their vineyards in several northern U.S. states have been summarized in recent publications. In Nebraska (NE), located in the continental Great Plains region, the development of the grape and wine industry since the 1990s has been affected by changes in consumer behavior, increased marketing efforts and focus on wine tourism, reduced profitability of traditional row crops, and the availability of new grape cultivars suited to the hot summer /cold winter climate in the state (Read, 2004). Among 39 cultivars trialed in NE from 1998-2013, ten have been identified as reliable producers within the region and another fourteen have been recommended for trial plantings (Read and Gamet, 2016). That research was conducted at three research sites with average winter minimum temperatures of -24, -27, and -35°C. Cultivars recommended in the coldest sites were all American hybrids predominantly from UMN and Swenson breeding programs, including 'Frontenac', 'deChaunac', 'St. Croix', 'La Crescent' and 'Brianna'. In North Dakota, also located in the Great Plains region but north of Nebraska and South Dakota, winter temperatures below -35°C are common and growing degree day (GDD) accumulation is as low as 1200 (base 10°C) which limits the production of less cold-hardy grapes and presents difficulties in ripening many cultivars in that state (Hatterman-Valenti, et al., 2016).

Winegrape production in states east of the Great Plains including MN, WI, and Iowa (IA) has grown substantially since the 1990s, likely due to a clustering of research and outreach activity there. Total vineyard acreage in each state ranges from approximately 325-400 ha (USDA, 2012). Economic contribution of winegrapes to each states' economy was estimated at US$ 59-71 million annually (Tuck and Gartner, 2014a; Tuck and Gartner, 2014b; USDA, 2012). Individual vineyard size in those states is small, with 66-80% of vineyards under 2 ha. Cultivars planted are predominantly the MN and WI hybrids including Marquette, Frontenac, St. Croix, La Crescent, La Crosse, and Brianna {Tuck, 2014 #1599;Tuck, 2014 #1600}. In the Great Lakes and Mid-Atlantic regions of Michigan, Ohio, New York, Pennsylvania, and New Jersey, as well as the southern New England region which includes Connecticut, Massachusetts, and Rhode Island, the winegrape industries are based primarily on cold-hardy *V. vinifera* and French hybrid cultivars, although colder areas of those regions are experiencing increases in vineyard plantings supported by the

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availability of newer cold-hardy cultivars from the UMN and Swenson breeding programs (Cattell, 2013).

VERMONT GRAPE PRODUCTION STATISTICS

Vermont is located in the northern New England region of the northeastern U.S. along with New Hampshire and Maine. It is climatically different from southern New England states, which are generally warmer overall. Vermont climate is variable, depending mainly on elevation and, to a lesser degree, latitude factors (Dupigny-Giroux, n.d.). Latitude is between 42.7 and 45.0° and longitude between -73.2° and -71.6°. Topography is characterized by: the Lake Champlain Valley to the northwest; Taconic Mountains and Otter Creek Valley to the southwest; the centrally located Green Mountain range that bisects the state; Piedmont area east of the Green Mountain range;, the Vermont Highlands in the northeast, and Connecticut River Valley in the east. Elevations range from 30 m ASL at Lake Champlain, to over 1300 m ASL in the Green Mountains, and back to 60 m ASL at the Connecticut River in the southeast. Climate is classified as mid-latitude wet (Köppen-Geiger classification Dfb) and USDA cold hardiness zones range from 3b (minimum winter temp -37.2°C) in the Green Mountains and Northeast Highlands to 5b in the Champlain and Connecticut Valleys. Important agricultural crops include dairy, beef, hay/forage, maple syrup, apples, mixed vegetables and berries. Total agricultural production is valued at US$ 776 million, with total value of fruits, nuts, and berries at US$ 13 million in 2012 (USDA, 2012). Commercial Vermont vineyards are primarily located in the Champlain Valley and Piedmont regions characterized by milder winter low temperatures (USDA plant hardiness zones 4b-5a) and soils composed from glacial and/or lake deposits (Trazskos, 2015).

Vineyard area and production

Winegrape production occurs in an estimated 65 ha of vineyards in Vermont, and estimated fruit production when vineyards reach full maturity will be over 270 t annually (NASS, 2015; Vermont Sustainable Jobs Fund, 2013). In 2013, the economic contribution of cold-hardy grapes, wine, and winery tourism in the six New England states was estimated at US$37.3 million annually (Tuck and Gartner, 2013). Complete statistics are not available specifically for Vermont vineyards, but in Tuck and Gartner's survey of New England grape growers, 21% of vineyards were larger than 2 ha, and 38% were less than 0.4 ha in size. Eighteen Vermont growers responded to that survey, but the total number of growers in Vermont is likely much higher. Statistics are not available for total number of grape growers in the state, but the University of Vermont (UVM) Cold Climate Grape stakeholder email list contains 263 subscribers, although that number includes participants from outside the state as well as industry support partners that do not produce grapes.

Economics of Vermont grape production

An economic analysis of grape production in Vermont conducted by Cannella (2015) evaluated potential profitability for vineyards in the state to produce fruit for wineries. Growers surveyed in the study reported grape prices of US$ 1814/t, which are similar to USDA statistics reported for Vermont growers but 2 to 2.5 times higher than prices reported for hybrid grapes in neighboring New York (Cornell NY Grape Program, 2016; NASS, 2015). Given expected mature yields of 9 t/ha, an 8 ha vineyard in Cannella's study was projected to reach cumulative net profitability at Year 19 from planting. Because of efficiencies of scale, smaller vineyards which are common in Vermont or those with lower crop prices or yields are not expected to reach net profitability within twenty years from planting. However, many vineyards are operated by wineries that increase the value of raw fruit and thus increase potential for profitability. Many

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smaller vineyards (>0.4 ha) are also operated as hobby operations and do not sell fruit or produce wine commercially (Cannella, 2015).

MATERIALS AND METHODS

Vermont grape producers were sent a survey in spring 2016 which included questions on: grower demographics; market distribution of grapes grown; perceptions on importance of production challenges for their vineyard; and vineyard information including year of planting, cultivar, training system, and crop yield at maturity. The survey was publicized twice through UVM Grape Program email lists and blogs. Nine Vermont growers responded to the survey, but two were removed because of incomplete datasets and/or production of less than 100 vines. The seven remaining commercial growers reported 17.84 total ha of vineyards which represents 27% of the state's vineyard acreage. Data were tabulated in Microsoft Excel 2016 and descriptive statistics are presented.

Grower demographics

Table 1. Demographic characteristics of Vermont vineyard operators (n=7).

Respondent	# years growing grapes	# years working in agriculture	Used crop insurance	Made commercial wine	Sold grapes to wineries
1	15	40	yes	yes	yes
2	18	18	yes	yes	no
3	14	14	no	yes	no
4	4	6	no	yes	no
5	9	18	no	no	yes
6	3	3	no	no	no
7	6	6	no	yes	no
Mean	9.9	15.0	28.6%	71.4%	28.6%

Respondents reported growing grapes for an average of ten years, however, several had produced for six years or less (Table 1). Similarly, average years the operator worked in agriculture was 15.0, but several producers had worked six years or less in the field and over half had only worked in agriculture as long as they had operated a vineyard. Two operators used crop insurance programs supported by USDA to reduce risk from weather or other-related failure of the crop. Five respondents made their own commercial wine from the crop, and two sold grapes to wineries. The high proportion of growers who also made wine is indicative of the inherently low value of the unprocessed grapes which attain their greatest value only when made into wine.

Six of seven growers ranked weather-related damage and disease management as important threats to their operations (Table 2). Weather-related damage had the highest mean rank of the perceived threats, likely due to the frost susceptibility of many cold-hardy cultivars and potential for crop damage from hail, flood, or drought. Canopy management had the second highest mean rank. Grapes require extensive management of vegetative growth in the canopy to reduce shading on fruit and improve juice quality and cold hardiness, and this activity is among the most labor-intensive in hybrid vineyards (Smart and Robinson, 1991). Disease management ranked the third highest overall. Disease susceptibility for cold-hardy hybrid grape cultivars is substantially lower than for *V. vinifera*, however, diseases such as black rot and anthracnose may destroy an entire crop if left unmanaged (Berkett, 2009; Weigle and Muza, 2016). One respondent included lack of suitable available cultivars as a threat, but ranked it only third among five. Insect pest management was rated as important by five respondents, but mean rank of 3.40 suggests that the relatively few insect pests of grapes in the region are relatively easy to manage.

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Horticultural factors including site selection, groundcover management, and vine nutrition were included by several respondents but not highly rated as threats. Surprisingly, given the long period to reach cumulative net profitability in commercial vineyards described by Cannella, only two respondents included poor profitability or low prices as a threat, and both ranked it at the bottom among five.

Table 2. Respondent's ranking of greatest perceived threats to their vineyard operations.

Weather-related damage	Canopy management	Disease management	Availability of suitable cultivars	Insect management
1.67[z] (6)[y]	2.20(5)	2.83 (6)	3.00 (1)	3.40 (5)
Site selection	Groundcover management	Vine nutrition	Low crop price or vineyard profitability	Poor juice quality
3.50 (2)	3.75 (4)	3.75 (4)	5.00 (2)	0

[z] Mean ranking where 1=greatest threat.
y Number of respondents who ranked each threat within their top five.

Year of vineyard establishment

Survey responses indicated that only three vineyards were planted in 1999, and two in 2002 (Figure 1). All other vineyards were established between 2006 and 2014. Some early vineyards were not captured in this survey; other reports have indicated several vineyards in the state were established from 1998-2000 (Trazskos, 2015). Also, several plantings from 2006-2014 known by the authors were also not captured in the survey reported herein. However, the survey does cover 27% of the acreage planted in the state, including both mature and younger vineyards, and is assumed to be representative of the industry.

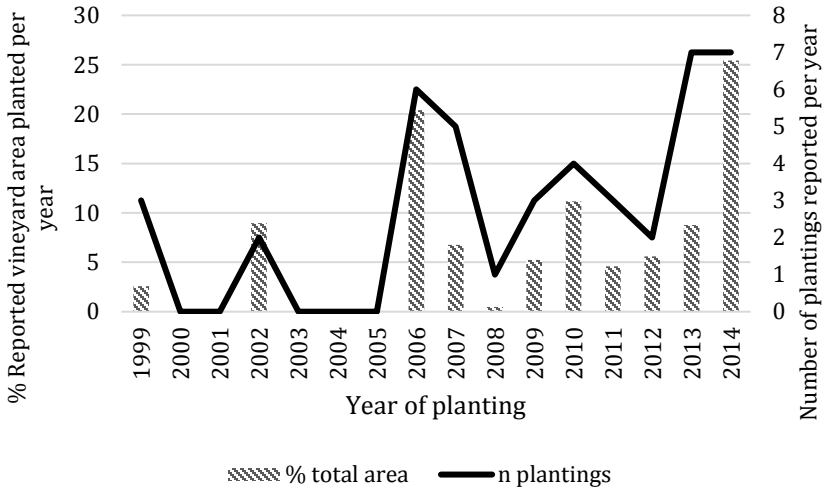

Figure 1: Year of establishment for respondents' vineyards

Cultivars and training systems

Vineyard planting years ranged from 1999-2014. Cultivar adoption among responding growers was weighted heavily toward relatively recent cultivars from public and private breeding programs in the upper midwestern U.S., with a few exceptions such as the *V. vinifera* cultivars 'Riesling' and 'Arctic Riesling' (Table 3). These cultivars were planted in 1999 by one

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respondent. Average crop yield at maturity for these two cultivars was less than one-third the target yield of 9 t/ha for hybrid grapes, likely due to poor cold hardiness. The only French American hybrid cultivar reported in the survey was 'Vidal', which was in three vineyard plantings. Average year of planting was 2008, but the high deviation (sd= 7.81) suggests that 'Vidal' was being planted throughout the vineyard establishment years of 1999-2014. Reported yield was half of the target yield, but 'Vidal' is commonly used to make high-value ice wine, and that process may reduce harvestable yield but increases the profitability of the cultivar (Hope-Ross, 2006). Although not widely reported in this survey, some production of other French Hybrid cultivars including 'Baco Noir', 'Leon Millot', 'Marechal Foch', 'Seyval Blanc', and 'Vignoles' are maintained at a few vineyards in Vermont (Trazskos, 2015). Although the acreage for these cultivars is not known, it is unlikely they represent a large percentage of total grape acreage in the state.

Table 3. Winegrape cultivar distribution and planting year of Vermont vineyards.

Cultivar	n [z]	Mean year planted [y]	ha reported	% of total ha	Crop yield (t/ha)
Arctic Riesling	1	1999.0 ± 0.00	0.10	0.6	2.69
Riesling	1	1999.0 ± 0.00	0.24	1.3	2.69
Frontenac	5	2007.4 ± 5.81	2.39	13.4	6.56
La Crescent	3	2007.7 ± 2.08	2.11	11.8	6.28
St Croix	2	2008.0 ± 1.41	0.45	2.5	7.40
Vidal	3	2008.0 ± 7.81	0.52	2.9	4.26
Louise Swenson	4	2009.0 ± 3.56	1.04	5.8	8.14
Marquette	10	2009.2 ± 2.93	6.57	36.8	6.96
Frontenac Gris	2	2010.5 ± 4.95	0.60	3.4	8.52
Prairie Star	2	2010.5 ±0.70	0.41	2.3	4.48
Adalmiina	1	2011.0 ± 0.00	0.10	0.6	6.73
Frontenac Blanc	2	2011.5 ± 3.54	0.53	3.0	8.52
Petite Pearl	6	2012.8 ± 1.64	2.12	11.9	8.97
Brianna	1	2014.0 ± 0.00	0.67	3.7	na
Total/average		2008.4 ± 4.34	17.84	100.0	6.32

[z] Number or blocks reported by respondents. One respondent may have reported multiple plantings of a cultivar.

[y] Mean year of planting for all blocks of a particular cultivar.

Cold-hardy UMN and Swenson cultivars comprised 95.2% of vineyard area reported in this survey. The earliest–planted cultivars 'Frontenac' and 'La Crescent' were among the first released by the University of Minnesota, and a standard deviation of 5.81 years indicates that 'Frontenac' has been planted throughout the period 1999-2014 reported in this survey. 'Marquette', which produces a red wine, had the greatest production area at 36.8% of the total reported. 'La Crescent' was the primary white grape planted at 11.8%. 'Louise Swenson' and 'Prairie Star' are also white grapes which collectively accounted for 8.1% of total vineyard acreage. Newer releases including 'Adalmiina', 'Frontenac Blanc', and 'Petite Pearl' are represented in later plantings in the survey. The red wine grape 'Petite Pearl' was first planted in 2010 but comprised 11.9% of reported vineyard area. 'Brianna' was the most recently planted cultivar reported in the survey, despite its release 15 years ago in 2001. Mean crop yield was higher on the cold-hardy hybrids than the French American or *V. vinifera* cultivars, although few reached the target of 9 t/ha. This may be explained by the presence of younger plantings in the

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survey data which would have less yield compared to mature plantings. However, 'Petite Pearl' achieved target yields despite being one of the most recently planted cultivars in the survey.

Table 4: Training system distribution in Vermont winegrape vineyards

Training system	n [z]	Mean year planted [y]	ha reported	% of total ha	Crop yield (t/ha)
Geneva double curtain	6	2005.3 ± 2.8	4.53	25.4	8.83
High wire cordon	23	2010.2 ± 2.6	7.81	43.8	6.87
Mid wire cordon (VSP)	14	2008.7 ± 6.1	5.50	30.8	4.05

[z] Number of blocks reported by respondents. Each respondent reported multiple plantings of a training system.

Cold-hardy hybrids do not tend to have the upright growth habit of *V. vinifera* and therefore, training systems may be different than those used for classic winegrapes. In this survey, six vineyard blocks were reported to be grown on Geneva Double Curtain (GDC) training system. This divided canopy system was developed in New York in the 1960s to manage excessive vigor on high fertility soils (Shaulis, et al., 1967). Five of six blocks trained to GDC were from a single vineyard which adopted the system to manage high vigor, and the early mean planting date confirms that this system is not continuing to be widely adopted. GDC vineyards reported the highest crop yield, and this reflects the use of the system on high vigor sites and the age of the vineyards using it which are likely all at full maturity. The majority of plantings were trained to the high wire cordon (HWC) system in which permanent cordons are tied to a 1.8 m high wire and all vegetative growth combed downward during the growing season. Grapes are produced in a fruiting zone within 0.3 m of the wire and foliage is removed within this zone to encourage even fruit ripening (Wolf, 2008). HWC vineyards had the second-highest yield after GDC, but the later planting dates suggest that many are not yet in full production. Traditional mid wire cordon or vertical shoot positioning (VSP) training was used in 30.8% of the vineyards in the survey, and the high standard deviation for planting year indicates that the system has been adopted throughout the 1999-2014 reporting years. Crop yield was lowest on this system, which reflects its use for upright-growing *V. vinifera* and less cold-hardy French hybrids, as well as its adoption on a number of young plantings in 2014. Research has concluded that VSP produces lower yield on several cold-hardy cultivars, and that system is generally not recommended for them (Ferrandino, 2015; Martinson and Particka, 2015a; Martinson and Particka, 2015b).

CONCLUSION

The Vermont winegrape industry represents a unique growth sector for specialty crops production in the state. The world's great wine regions have selected cultivars, training systems, and management practices over the course of decades if not centuries, and the Vermont industry is at the beginning of its development. As new cultivars are released, management practices are refined, and winemaking standards are optimized for particular cultivars, the wines of Vermont have potential to compete with those of traditional wine regions. Continued research and outreach on the important components of viticulture and enology are critical to support this valuable industry.

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