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‘Clarion’ Grapevine: A White Wine Cultivar for Midwest United States Production

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The University of Minnesota Agricultural Experiment Station has released several cultivars for cold-climate wine production. Clarion (*Vitis* hybrid) is the newest cultivar that was bred for use in the Midwest in the United States, and it has exhibited the ability to survive and produce high-quality fruit in the United States Department of Agriculture (USDA) Hardiness Zone 5 (average minimum temperature, −23.3 to −28.9 °C); furthermore, it has moderate survival in Zone 4. ‘Clarion’ has been tested in Wisconsin and Iowa, among other Midwest states, and its fruit quality and growth habit make it an ideal cultivar for production in that region. Although less cold-hardy than Itasca, Frontenac gris, or Frontenac blanc, this cultivar has juice chemistry that is similar to that of Itasca, which is suitable for dry-style wines. ‘Clarion’ produces wine with a unique, light, aromatic profile and an acid level that is lower than that of ‘La Crescent’.

Origin

‘Clarion’ resulted from a cross of VB86–04 × ‘Frontenac’ in 1992 (Fig. 1). The selection was first identified and tested at the Horticultural Research Center (HRC), a Minnesota Agricultural Experiment Station located near Excelsior, MN (lat. 44°52′9.2496″ N, long. −93°38°15.435″ W). The seedling vine originated from a cross pollination conducted by Valentin Blattner in Switzerland in collaboration with Peter Hemstad; it was evaluated in Minnesota, which is part of the United States Department of Agriculture (USDA) Hardiness Zone 4. The maternal parent VB86-04 is a complex *Vitis* hybrid originating from Seyval blanc × Pinot Noir, and the pollen parent Frontenac is a well-known hybrid wine grape cultivar derived from *Vitis riparia* 89 × Landot 4511 (Luby and Hemstad, 2003). The resultant hybrid cultivar Clarion (shown in Fig. 2) has an extensive pedigree tracing through several species, including *V. vinifera*, *V. lincecumii*, *V. berlandieri*, *V. riparia*, *V. labrusca*, and *V. rupestris*, among others. The seedling vine was designated as MN 1220 in 1998, because of its desirable fruit quality attributes and growth habit, and it was propagated through hardwood cuttings for clonal evaluation. ‘Clarion’ was patented in 2022 as USPP 34,794.

Description and Performance

Growth and yield. The primary evaluation was conducted at the HRC; however, the clones were also tested by NE1020: Multistate evaluation of wine grape cultivars and clones. Those data are referenced specifically as those presented by Iowa State University, Ames, IA (Schrader et al. 2019, 2020) and University of Wisconsin, Madison, WI (Scharfetter et al. 2020), which served as additional evaluation sites. Three vines of this selection were cloned and planted into a second test evaluation site in 2000; further clones were planted into separate vineyard blocks at the HRC in 2006, 2009, and 2010. The evaluations presented represent data collected from the original seedling vine as well as the clonal test blocks. Data were analyzed using R (R Core Team 2022) to calculate the means and conduct an analysis of variance. A post hoc means separation was conducted using Fisher’s least significant difference to compare cultivars. ‘Clarion’ was compared with other cold-hardy, hybrid wine grapes, including its parent ‘Frontenac’, during the evaluation. The maternal parent, VB86-04, was trained to a mini-J system with vertical shoot positioning, and vines were removed from the trellis and covered with straw each winter to prevent injury (Hoover, 1986), thus making it unsuitable for many growth trait comparisons. The HRC vineyards have a minimal spray program to allow for the evaluation of resistance to insect pests and diseases. Vines were grown on their own roots, as is the typical practice for cold-climate grapevines. The vines were trained to a top wire, high-cordon system and grown bilaterally with multiple trunks (with trunks within a plant having two different ages). Replacement trunks were trained as needed from suckers to replace dead or injured trunks. Vines were dormant-pruned each year, and weeds were controlled through a combination of mechanical and chemical methods, including preemergent and postemergent herbicides. ‘Clarion’ is less vigorous than ‘Itasca’, ‘Frontenac’, La Crescent’, and ‘Marquette’ based on observations at the HRC; this was confirmed by pruning weights reported by Schrader et al. (2019) when grown in Iowa.

The mean cluster weight for ‘Clarion’ was 106.9 g (range, 77.5–127.3 g) between 2010 and 2019, at the HRC. In Iowa, Schrader et al. (2019) reported smaller cluster weights with an average of 69.7 g. This cluster weight is comparable to that of ‘Itasca’ (145.0 g), ‘La Crescent’ (86.8 g), and ‘Frontenac’ (123.6 g). The average berry weight (calculated from 50 berries) was 1.48 g (range, 1.19–1.77 g) at HRC and 1.55 to 1.59 g in Wisconsin (Scharfetter et al. 2020). The yield per vine was 3.05 kg, which was not significantly different from that of ‘Brianna’ or ‘Itasca’, but it was less than that of ‘La Crescent (5.15 kg) in Minnesota (Table 1). During the Wisconsin NE1020 trial, the average yield per vine from 2012 to 2018 was 9.75 kg. Additional data collected at Iowa State University for the NE1020 trial have been reported by Schrader et al. (2019).

Winter hardiness and phenology. Midwinter cold-hardiness was assessed using a destructive sampling technique to dissect eight compound buds on each of six representative canes collected annually in February or March to determine primary bud survival. Assessments were performed from 2009 to 2019, and the primary bud survival ranged from 4.2% (polar vortex event in Winter 2013–14) to 97.9% in 2011 to 2019. During 9 of 11 years, the primary bud survival rate was ≥80%. The lowest temperatures recorded at the Chanhassen Weather Service Forecast Office in Minnesota was −31.7 °C on 21 Jan 2011, followed by −35.0 °C on 1 Jan 2019, and the primary bud survival rates of ‘Clarion’ were 97.9% and 60.0%, respectively.

‘Clarion’ exhibited more bud freeze injury than ‘Itasca’ and ‘Frontenac’, and its color is similar to that of ‘Frontenac gris’, ‘Frontenac blanc’, and ‘Marquette’ when grown in the USDA Zone 4. To mitigate winter injury, ‘Clarion’ was trained to multiple trunks as a common practice to replace damaged trunks and canes as recommended. This is a recommended practice in Minnesota. In Iowa, the primary bud survival was not different from that of ‘Frontenac’, ‘Marquette’, or ‘La Crescent’ (Schrader et al. 2019).

Disease resistance. Based on field observations over the course of multiple years, Clarion was less disease-resistant in Minnesota than the other cold-hardy cultivars, especially Itasca. ‘Clarion’ displayed moderate susceptibility

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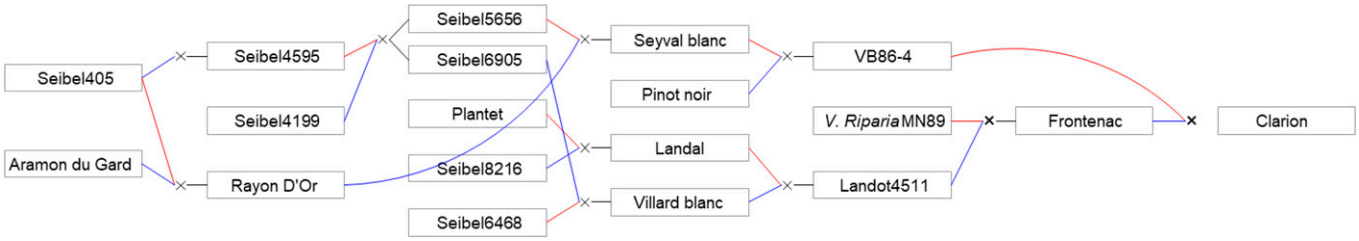

Fig. 1. Pedigree of 'Clarion' grapevine through five generations. The line color indicates the parental configuration (red = female; blue = pollen).

Fig. 2. 'Clarion' grape clusters at maturity as photographed at the Horticultural Research Station in Excelsior, MN (University of Minnesota Ag. Experiment Station).

Table 1. Grape production characteristics including the mean yield per vine, berry size, and juice chemistry analysis at harvest (mean and standard deviation) at the University of Minnesota Horticultural Research Center, Excelsior, MN, 2010–19. Cultivar means within columns with different letters are significantly different ($P < 0.05$) with respect to Fisher's least significant difference (LSD) post hoc analyses.

Cultivar	Yield (kg)	*SD*	pH	*SD*	TTA ($g \cdot L^{-1}$)	*SD*	Malate ($g \cdot L^{-1}$)	*SD*	SSC (°Brix)	*SD*	FAN ($mg \cdot L^{-1}$)	SD	Harvest window
Clarion	3.05 b	1.46	3.21 a	0.08	8.71 cd	1.70	3.40 c	0.98	24.18 a	1.11	192.00 ab	11.31	14 Sep–9 Oct
Brianna	3.05 b	1.46	3.13 ab	0.19	7.43 d	1.66	2.80 c	1.22	19.24 c	2.79	161.67 ab	33.20	12 Sep–28 Sep
Frontenac gris	4.28 ab	1.78	3.06 b	0.10	13.13 a	0.75	6.43 a	1.33	25.58 a	1.64	215.89 a	39.37	11 Sep–14 Oct
Itasca	3.34 b	1.24	3.20 a	0.13	9.16 c	1.37	3.05 c	1.63	25.20 a	1.75	89.00 c	32.74	14 Sep–2 Oct
La Crescent	5.15 a	2.40	3.04 b	0.08	13.25 a	2.24	7.33 a	1.10	22.38 b	0.84	131.50 bc	3.54	30 Aug–6 Oct
Marquette	4.15 ab	1.52	3.04 b	0.10	11.27 b	1.75	4.63 bc	0.79	24.75 a	1.80	159.33 b	29.69	6 Sep–29 Sep

Yield per vine is estimated from mature vines on 6- or 8-foot spacing in several vineyard locations across years 2010–18. No Fisher's LSD was provided because of the unbalanced design.

Measures of acidity [pH and total titratable acidity (TTA) as tartaric acid equivalents], malic acid (MA), soluble solids content (SSC), and free amino nitrogen (FAN) were performed over the 10-year period.

to powdery mildew (*Erysiphe necator*) on leaves, rachis, stems, and fruit. This level of susceptibility is normally controlled through well-timed fungicidal spray treatments. Similarly, black rot (*Guignardia bidwellii*) susceptibility was moderate to high, but it was typically managed concurrently with fungicide sprays before and after bloom. Molecular data of 'Clarion' support *RPV3.1* and *RPV3.2* resistance to downy mildew (*Plasmopara viticola*), and no leaf and fruit infections have been observed. Furthermore, no infections caused by gray mold (*Botrytis cinerea*) or crown gall (*Agrobacterium* sp.) were observed.

Canopy management. 'Clarion' vines had lower vigor than 'Itasca', 'Marquette', 'Frontenac', and 'La Cresent'. The vine has limited to no mid-season lateral shoot growth, in contrast to 'Marquette'. Pruning weight data were collected in Iowa, as reported by Schrader et al. (2020), with 'Clarion' having a pruning weight of 486.7 g with 2.4-m vine spacing. The 'Marquette' pruning weight was 896.0 g, and that of 'La Crescent' was 719.1 g (Schrader et al. 2020). In Wisconsin, the average pruning weight from 2015 to 2017 for 'Clarion' was 861.8 g.

Enological performance. Wines have been made from 'Clarion' grown at the HRC for more than 15 years, and the data presented in Tables 1 and 2 reflect data collected annually from 2010 through 2019. In each year, a standard protocol was used for microvinification in volumes ranging from 11 to 22 L. Berries were harvested from plots and pooled for analysis and winemaking. Harvest maturity was determined using flavor, aroma, appearance, and basic juice chemistry data [soluble solids content (SSC), pH, and total titratable acidity (TTA)]. The range of harvest dates reflects the annual variation in growing conditions each year as well as a typical practice in the Midwest that allows fruit to mature on the vine to increase aromatic compounds and reduce organic sugar

Table 2. Wine composition attributes of Clarion wine and other cold-hardy grape cultivars grown at the Horticultural Research Center, Excelsior, MN. Cultivar means within columns with different letters are significantly different ($P < 0.05$) with respect to Fisher's least significant difference post hoc analyses.

Cultivar	pH	*SD*	TTA (g·L^{-1})	*SD*	% Ethanol (volume/volume)	*SD*
Clarion	3.25 b	0.07	7.27 bc	0.63	13.84 ab	0.69
Brianna	3.25 b	0.15	7.25 bc	0.95	13.5 ab	1.10
Frontenac gris	3.15 b	0.26	11.30 a	1.84	14.07 a	1.11
Itasca	3.13 b	0.10	8.12 b	1.11	14.4 a	0.82
La Crescent	3.22 b	0.16	10.14 a	1.54	13.13 b	0.13
Marquette	3.52 a	0.10	6.45 c	0.67	14.23 ab	0.48

content. Wines were produced according to the protocol outlined by Clark et al. (2017).

Juice and wine analysis. Leading up to harvest, grapes were monitored for maturity through the assessment of flavor, visual changes, and field chemistry analysis results. The crop was typically harvested when fruit were ~24°Brix. At harvest, berries were crushed and juice samples were aliquoted for analysis. The SSC (in °Brix) was measured with a handheld digital refractometer (Atago Pocket Pal-1; Atago USA, Bellevue, WA). The pH was measured using an Accumet AR15 pH meter (Fisher Scientific, Hampton, NH), and the TTA (in g·L^{-1} tartaric acid equivalents) was measured using a Mettler-Toledo DL28 titrator and the DG115-SC pH probe with autosampling (Mettler-Toledo, Columbus, OH). Juice was also evaluated by performing an enzymatic analysis (UniTAB™, Unitech Scientific, Hawaiian Gardens, CA) to determine the free amino nitrogen, yeast assimilable nitrogen, and malic acid concentrations.

Juice data at harvest. Average data of the juice composition reported for 2010 to 2019 are reported in Table 1. An analysis of variance was conducted and a post hoc means separation analysis using Fisher's least significant difference test were completed in R (R Core Team 2022). Clarion juice had a pH (3.21) similar to that of all other cold-hardy cultivars described. The TTA for 'Clarion' (8.71 g·L^{-1}) was comparable to that of 'Itasca' (9.16 g·L^{-1}) and slightly higher than that of 'Brianna' (7.43). The malate level of 'Clarion' was approximately half that of 'Frontenac gris' and 'La Crescent', thus contributing to the lower overall perception of sourness of 'Clarion'. This lower malic acid level is favorable for winemaking, especially when producing dry wines. 'Clarion' has a relatively high SSC at harvest (24.18 °Brix), which is comparable to that of 'Frontenac gris', 'Itasca', and 'Marquette'. The yeast assimilable nitrogen level of 'Clarion' was 201.0 mg·L^{-1}, which was similar to that of 'Marquette' and 'Briana' (data not shown). 'Clarion' had a moderate free amino nitrogen level of 192.0 mg·L^{-1} (Table 1). These values, although not excessively low, do require additional monitoring, and nitrogen supplementation is necessary during winemaking to ensure full fermentation and improve the flavor and aroma (Bely et al. 1990). Scharfetter et al. (2020) reported the total protein of Wisconsin samples grown in 2017 in shaded and exposed fruit treatments. 'Clarion' had 15 and 24 mg/L lower total protein levels than 'La Crescent' when compared to those of the shaded and exposed fruit treatments, respectively. The total tannin concentration and total phenolics were also significantly lower in 'Clarion' than 'La Crescent' in both treatments (Scharfetter et al. 2020).

Wine composition data. At the end of fermentation and stabilization, wines were measured to determine the pH, TTA, and ethanol percentage (Table 2). For Clarion, the pH was 3.25, which was not different from that of any other cultivar except for Marquette, and was well within the normal range for wine stability. The TTA decreased during fermentation as expected, with that of 'Clarion' (7.27 g·L^{-1}) being comparable to that of 'Brianna' (7.25 g·L^{-1}) and 'Itasca' (8.12 g·L^{-1}). The reduction in TTA for 'Marquette' from juice to wine sample was a major change and a result of malolactic fermentation (secondary fermentation), which is used during the making of red wines. However, it is not used for the other cultivars (of the white wines evaluated). The average ethanol percentage by volume for 'Clarion' was 13.84% and was reflective of the SSC in the juice sample; however, it was not significantly different from that of any other sample observed during this study.

Juice and wine sensory attributes. The sensory evaluation of this cultivar has been primarily limited to the project staff, who tasted notes of fresh fruit at harvest; blind wine sensory evaluations have been performed as well. The berries are small and seeded. Therefore, they are not generally considered desirable or suitable for fresh eating; however, they have pleasant aromatics and a sweet flavor. The fruit flavors have been described as neutral with light aromas (floral notes including lilac and tropical fruits). 'Clarion' lacks muscat aromas, *V. labrusca* foxy aromas, and strong herbaceous aromas found in *V. riparia* compared with 'La Crescent', 'Concord', and 'Frontenac', respectively.

'Clarion' has been used to make fine, quality wines with subtle flavors and aromas. Project staff evaluate wines in the spring after each vintage during blind tastings; ~10 unique samples are evaluated. Tasting notes and descriptors from these evaluations include aromas of pear (flower, fruit skin), honey, chamomile, citrus, mineral, and herbal. Other aromas identified during the routine sensory analysis include apricot and peach, honeydew melon, and light herbaceous aromas. The lower acidity compared with that of many other cold-climate wine cultivars contributes to the balance of the wine, suitability for dry cultivar wines, and use in blending.

Availability

'Clarion' is currently available for nurseries wishing to grow and distribute the vines. A United States Plant Patent (34,794) has been assigned to this cultivar. A license agreement must first be signed, which can be arranged with the University of Minnesota Office of Technology Commercialization. More information can be found at http://mnhardy.umn.edu/commercial-growers/license/license-grapes. For a list of current licensees, or to inquire about a license agreement for the propagation and sale of 'Clarion' grape vines, visit mnhardy.umn.edu/clarion.

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