February 3 – 4, 2023 Post Freeze Report: Nova Scotia Wine Grape Initial Impact Assessment

February 2023

This report was produced by the Agriculture and Agri-Food Canada (AAFC), Kentville Research and Development Centre (KRDC) Plant Physiology Program in collaboration with Perennia. We wish to acknowledge the contributions from the Grape Growers' Association of Nova Scotia and Wine Growers Nova Scotia.

Summary

- Freeze event: These were the coldest, widespread temperatures observed in Nova Scotia since 2009 and the fourth coldest annual minimum (Kentville site) in 50 years.
- Historically warm start to winter: The average December and January temperature (Kentville, +0.5 °C) was the warmest on record (since 1914). The annual extreme minimum temperatures observed in the second (1958) and third (2021) warmest starts to winter were much higher.
- Temperature and acclimation: Due to a lack of moderate cold temperatures preceding the February 3 – 4 freeze event, wine grape varieties were 1 °C to 3 °C less hardy than in a "typical" year. Historic warm followed by record cold is a horticulturally damaging combination. The lack of acclimation means damage to the vines was ~15% to 45% greater, depending on the variety, compared with what would have been expected at these same minimum temperatures after a more typical start to winter.
- Bud damage and 2023 vintage impact: The results from the province-wide bud viability assessment indicate there will be almost no *vinifera* (≈ 30% of acreage) crop in 2023. The impact on hybrid varieties (≈ 70% of acreage) is more nuanced. Sensitive hybrids (e.g., New York Muscat, Seyval and Vidal blanc) were heavily damaged. The crop in medium-hardy varieties (e.g., L'Acadie and Leon millot) will be down markedly, but will range from no crop to a moderate crop at the least damaged sites with pruning adjustments. Many hardy Minnesota variety sites (e.g., La Crescent, Marquette, Frontenac, Petite Pearl) hold the potential for a moderate crop with pruning adjustments.
- Vine and long term vineyard damage: It is impossible to accurately assess the long term damage in the short term; time (1 to 2 years) will be needed for the full freeze impact on Nova Scotia vineyards to be realized. Current predictions suggest the majority of sites will recover; however, some sites may require more than one year for recovery or a replant. Management practices will be required for a good recovery.

Detailed Discussion

A Record Low Tempearture Preceded by a Historically Warm Winter

A distinction should be made between a winter advective freeze (i.e., freezing temperatures come with a moving air mass / wind / relatively uniform cold temperatures and damage within a localized area) and a winter temperature inversion event (i.e., little to no wind / cold air pools, large discrepancies in both temperature and potential damage in nearby sites or even within a site). Nova Scotia has experienced two notable winter temperature inversion events in recent years: Feb. 15, 2020 and Jan. 22, 2022. These events impacted a minority of sites (where cold air pooled), but the majority of sites avoided major damage. The February 3-4, 2023 event was an advective freeze event. Given the low temperatures reached, and unlike the past inversion events, damage is widespread. Additionally, unlike inversion events, wind fans, burning bails and other strategies meant to mix the air would have a negligible effect during an advective freeze event. Despite being an advective freeze,

there was a temperature gradient across mainland Nova Scotia that corresponded to latitude and the distance the air mass travelled on the prevailing west / northwest wind over the relatively warmer ocean and land mass (Table 1).

Table 1. Feb. 3 – 4, 2023 minimum temperatures recorded broken down by site and mainland Nova Scotia latitudinal zone. Note the homogeneity within each zone.

Zone	Temperature sensor sites (°C)	Avg min. temp (°C)*
Northern (N of 45° 10')	Caribou (-26.5), Malagash (-26.7), North Shore (-27.6), Wallace Bay (-27.7)	**-27.1**
Central (44° 35' to 45° 10')	Kentville (-25.5), Greenwood (-25.2), Wolfville (-25.2), Sheffield Mills (-25.2), Windsor (-25.2), Berwick (-25.4), Melvern Square (-25.4), Paradise (-24.9)	**-25.2**
Southern (S of 44° 35')	Bear River (-24.1), Bridgewater (-23.3), Mahone Bay (-24.0), Martins Point (-23.5)	**-23.7**

* Temperatures are a combination of Environment and Climate Change Canada, Mesonet and NS bud hardiness survey site sensors. Weather data was restricted to sensors located within or near areas where wine grapes are grown. Northern zone – northern Cumberland, Colchester and Pictou counties; central zone – Hants, Kings and Annapolis Counties; southern zone – Digby, Lunenburg and Queens counties.

Based on the Environment and Climate Change Canada Kentville site, the five annual minimum temperatures colder than the 2023 event (-25.5 °C) occurred in 2009 (Jan. 15, -26.1 °C), 1994 (Jan. 27, -28.0 °C), 1993 (Feb. 7, -30.0 °C), 1971 (Feb. 4, -27.2 °C) and 1957 (Jan. 16 ,-29.4 °C). Despite being only the fourth coldest annual minimum temperature to have occurred in the last 50 years, the 2023 winter minimum distinguished itself from all those that preceded it in one significant way: the preceding two months (December and January) were the warmest on record (avg = 0.5 °C). This record dates back to 1914. The average December and January temperature over the entire record (1914 – 2022) is -3.9 °C. The second warmest start to winter was in 1958 (avg = 0.3 °C) with an associated annual minimum of -18.9 °C; the third warmest start to winter was in 2021 (avg = 0.0 °C) with an annual minimum of only -15.8 °C. Historically, warm winters have higher annual extreme minimum temperatures (i.e., coldest temperature of the year) and colder winters have lower ones. The winter of 2022-2023 did not follow this trend.

2022-2023 Wine Grape Bud Hardiness and Acclimation

The temperatures preceding a significant winter minimum event are important because cool temperatures are needed for plants to acclimate to winter and to become hardy. Data taken from the KRDC wine grape bud hardiness survey demonstrate how the warm temperatures observed in the 2022-2023 dormancy season negatively impacted bud hardiness (Table 2). Bud hardiness is measured in terms of a bud's low temperature exotherm (LTE) value: i.e., the temperature at which the water contained within a bud turns from water into ice, resulting in bud death. The crop for the current season resides within these dormant buds. The data show that *vinifera* varieties included in the survey were, on average, 1.3 °C less hardy at the time of the 2023 low temperature event relative to previous years. Hybrid varieties included in the survey, while still hardier than *vinifera* in 2023, saw this margin shrink as a result of being 3.4 °C less hardy than normal in the days preceding the damaging low temperatures (Table 2). *Vinifera* vines were likely less impacted by the warm weather than hybrids as their genetics are more adapted to warmer growing regions. While a difference in hardiness of only 1 to 3 °C relative to in previous years may seem small, this is significant. To put these numbers into perspective, the difference between LTE10 (i.e., the temperature associated with 10% bud death) and LTE90 (i.e., the tempearture associated with 90% bud death) is 6.2 °C on average, according to the Nova Scotia bud

Table 2. Average LTE50 (50% bud mortality) (°C) values on Feb. 3 in 2023 vs previous 4-year average*

Variety	LTE50 (4-yr avg)	LTE50 (2023)	LTE50 diff.
vinifera			
Chardonnay	-24.8	-23.1	+1.7
Pinot Noir	-25.4	-24.7	+0.7
Riesling	-24.9	-23.4	+1.5
Hybrids			
L'Acadie	-28.8	-25.4	+3.4
Marquette	-29.7	-26.3	+3.4

* The bud hardiness survey data does not capture the northern zone, which may have been cooler / hardier.

hardiness 5-year average, and is relatively consistent between varieties and between vine type (hybrids and *vinifera*) based on NS data. To put this another way, once winter temperatures reach damaging levels, every additional 1 °C drop in temperature results in an additional 13% in bud mortality, on average.

Post-freeze bud viability / affected acreage

The acreage and bud viability levels were also broken down by latitudinal zone / growing region. While the bulk of vineyards are located in the central zone (≈ 82%), significant acreages are also found in the northern (≈ 13%) and southern (≈ 5%) zones (Table 3). Less hardy *vinifera* varieties are seperated from more hardy hybrids; fruitful primary buds are seperated from less fruitful secondary buds (Table 3). In general, secondary buds are rarely fruitful in *vinifera* varieties, but may be relativley fruitful in some hybrid varieties. Fruitfullness is dependent on variety and vine health.

Table 3. Wine grape acreage* and estimated (est.) bud viability** broken down by mainland Nova Scotia latitudinal zone, *vinifera* vs hybrid and primary versus secondary buds.

Zone	Est. *vinifera* acreage	Est. *vinfera* primary viability (%)	Est. *vinfera* secondary viability (%)	Est. hybrid acreage	Est. hybrid primary viability (%)	Est. hybrid secondary viability (%)
Northern	14.7	NA	NA	98.2	17.5%	29.1%
Central	152.7	0.9%	3.4%	515.8	22.6%	41.0%
Southern	10.3	1.2%	4.1%	30.2	48.4%	75.6%

* The most recent and comprehensive estimate of wine grape acreage is from 2018 (AAFC, Moreau. 2018). While overall acreage and the percentage of *vinifera* have increased in the years since this survey, the proportionaltiy across zones is still believed to be representative.
** Bud viability levels were based off a minimum of 100 compund buds being examined per cultivar and block in a subset of sites within each zone. Viability levels were weighted based on the acreage of the blocks sampled within each zone to generate estimates.

There will be no appreciable *vinifera* crop (≈ 30% of acreage) in 2023 (Table 3). The impact of this event on the hybrid varieties (≈ 70% of acreage) is more nuanced. The viability trend across the mainland Nova Scotia latitudinal zones followed the temperature gradient (Tables 2, 3); however, the bulk of the acreage is in the central zone, with the least damaged southern zone having by far the lowest acreage (Table 3). A full breakdown of the bud viability assessment by variety, site number, bud number, and primary and secondary viability can be found in Appendix A. In general, hybrid hardiness and damage ranged from only marginally hardier than *vinifera* (e.g., New York Muscat, Seyval and Vidal blanc), expected to have almost no crop in 2023, to moderately hardy (e.g., L'Acadie and Leon Millot) to highly hardy Minnesota varieties (e.g., La Crescent, Frontenac, Marquette and Petit Pearl). For grape sites with viability levels approaching zero, no pruning option will result in a crop worth harvesting. However, for sites that retain some level of bud viability, retaining extra buds at the time of pruning (not an option if the vine was already pruned at the time of the freeze) can bolster the crop: e.g., a vine with < 50% bud viability can still yield a modest crop if extra buds are retained. However, one must be careful to not over-crop a vine that may be in recovery (not a possibility in severely damaged vines) and to maintain a balance between vegetation and crop load. Having an accurate assessment of your bud viability levels broken down by variety and block prior to pruning will be paramount.

Whole vine / vascular damage

The possible vascular damage done to plants remains an unknown; whole vine (as opposed to bud) damage will likely require one to two years to assess the impacts. There are two stages to wine grape winter damage: stage 1 – bud death and the loss of the current year's crop; stage 2 – moderate to severe wood and vascular damage and the potential loss of the whole vine. While bud viability is relatively easy to assess, the same is not true of whole vine / wood vascular damage. Vines can tolerate and recover from low levels of vascular damage; however, moderate to severe vascular damage will result in weak vines that may take years to recover or the death of the vine. The impact depends on the degree of damage, variety and the health of the vine at the time of the freeze. Blocks with the highest risk of vascular damage will be those approaching zero percent bud

viability. Given the temperatures reached, it is believed that the majority of sites will eventually recover; however, some sites may require more than one year for recovery or a replant.

Questions regarding the content of this report can be directed to Dr. Harrison Wright at Harrison.Wright@agr.gc.ca.

Appendix A: provincial unweighted bud viability broken down by variety and primary and secondary bud. The approximate number of sites and buds assessed for each variety is also shown.

variety	site no.	bud no.	avg primary viability (%)	primary viability std dev	avg secondary viability (%)	secondary viability std dev
				vinifera		
Cabernet franc	1	100	0.0%	NA	0.0%	NA
Chardonnay	14	1400	1.3%	2.9	4.3%	3.0
Gamay	1	100	0.0%	NA	0.0%	NA
Muscat ottonel	1	100	0.0%	NA	0.0%	NA
Ortega	1	100	0.0%	NA	0.0%	NA
Pinot gris	1	100	0.0%	NA	0.0%	NA
Pinot meunier	2	200	0.5%	0.7	1.0%	NA
Pinot noir	9	900	0.8%	0.8	5.1%	3.1
Riesling	13	1300	1.8%	3.5	4.1%	5.7
Total	**43**	**4300**	**0.5%**		**1.6%**	
				hybrids		
Baco noir	5	500	28.6%	17.2	60.3%	20.3
Castel	1	100	46.0%	NA	29.0%	NA
Frontenac	5	500	60.7%	14.7	79.7%	19.9
Geisenheim 318	5	500	22.7%	21.5	47.2%	36.2
KW94-1	1	100	47.0%	NA	61.0%	NA
L'Acadie	27	2700	27.3%	14.7	50.3%	21.2
La Crescent	1	100	95.0%	NA	NA	NA
Leon millot	5	500	31.7%	14.7	58.9%	23.8
Lucie kuhlmann	6	600	12.1%	5.2	29.4%	12.5
Marechal foch	3	300	43.0%	31.8	68.0%	39.6
Marquette	6	600	60.7%	22.5	74.2%	15.9
NY muscat	10	1000	6.1%	5.3	22.9%	14.6
Osceola muscat	1	100	11.7%	NA	22.3%	NA
Petit milo	1	100	34.0%	NA	67.0%	NA
Petite pearl	2	200	39.3%	21.7	84.0%	NA
Seyval blanc	7	700	8.0%	9.8	7.9%	7.0
Triomphe	3	300	5.4%	7.7	27.8%	19.4
Vidal blanc	8	800	3.6%	5.9	15.6%	17.5
Total	**97**	**9700**	**32.4%**		**47.4%**	

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