February 15, 2020 Deep Freeze: perspective, wine grape bud viability assessment and lessons learned

Kentville Research and Development Centre (KRDC)

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Winter minimums and historical trends

In the early hours of February 15, 2020, the temperature at the Environment Canada weather station located at the Kentville Research Development Centre (KRDC) hit -21.7 °C; its counterpart in Truro, NS dropped to -29 °C. While the western Annapolis Valley saw relatively warmer minimum temperatures, the eastern Valley had unofficial, isolated lows of between -24 and -26 °C in the hardest hit areas. An account of how these low temperatures unfolded was recorded in the KRDC vineyard: temperatures reached their predicted low at around midnight with a 7 km h^{-1} wind, enough to limit a temperature inversion from forming. However, as the wind dropped to 2 km h^{-1}, an inversion did form. At 7:00, temperatures 1 m above the ground dipped to close to -25 °C, over three degrees *colder* than the temperature recorded only 8 m above (Table 1).

Table 1. Temperatures (°C) at 1, 2, 4, 6, 8 and 9 m in the KRDC vineyard in the early hours of Feb. 15, 2020.

	1 m	**2 m**	**4 m**	**6 m**	**8 m**	**9 m**
0:00	-16.97	-16.47	-16.64	-16.24	-16.44	-16.31
7:00	-24.63	-23.96	-23.35	-22.5	-21.46	-21.36

Such minimum temperatures have not been the norm in the last few years and the historical trend suggests winters are warming (Figure 1). If we evenly divide this dataset in two, there was a 37% chance of having a temperature < -25 °C in any given year in the earlier half, but only a 9% chance of the same in the latter. At the Kentville site, this marks the first time since 2015 that temperatures have even reached the -20 °C mark. However, even in recent memory, in the era that preceded the current rapid expansion of the wine grape industry, this was not always the case: prior to 2006, we must go all the way back to 1970 to find a winter that did *not* reach a low of at least -20 °C (Figure 1).

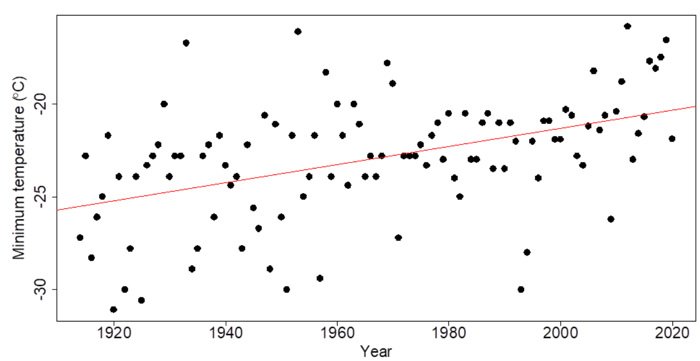

Figure 1. A plot showing the relationship between the year and dormant season minimum temperature (°C) from 1914 to 2020 as recorded at the KRDC Environment Canada site. The trend (y = 0.047x - 116) is positive and highly significant ($p < 0.001$), but variable ($R^2 = 0.20$).

Bud hardiness estimates

The February 15th event was also salient in that it marks the first time in the four years of the bud hardiness survey that temperatures dipped to lows that were predicted to be lethal for some sites and cultivars. The most recent predicted hardiness levels, prior to the morning of the cold snap, can be found in Table 2. Most vinifera ('Chardonnay', 'Pinot Noir' and 'Riesling') were predicted to sustain 10% bud mortality at temperatures between -18 to -20 °C and 50% mortality if temperatures were to reach ≈ -24 °C. The 'L'Acadie Blanc' vines were predicted to be a little hardier, with LTE10 and 50 values at -23 and -28 °C, respectively, and the 'Marquette' were predicted to be very hardy, with LTE10 and 50 levels of -29 and -31 °C, respectively (Table 2).

Table 2. Average bud hardiness levels, by cultivar, as predicted using differential temperature analysis (DTA) as of Feb. 3 – 5, 2020. Low temperature exotherm (LTE) values of 10, 50 and 90 predict the temperature levels needed to inflict 10, 50 and 90% bud mortality.

Core cultivars and sites	**LTE 10**	**LTE 50**	**LTE 90**
'Chardonnay' (5 sites)	-19.9	-23.9	-26.4
'L'Acadie Blanc' (6 sites)	-23.2	-27.8	-30.5
'Marquette' (3 sites)	-28.9	-30.6	-32.5
'Pinot Noir' (4 sites)	-18.6	-24.6	-26.9
'Riesling' (5 sites)	-19.7	-24.5	-26.9

Bud viability, impact & hardiness predictions accuracy

When a bud drops below its freezing point, the cells within that bud rupture, lose their integrity and turn black. Healthy buds, untouched by the low temperature event, generally maintain a vibrant green colour (Figure. 2).

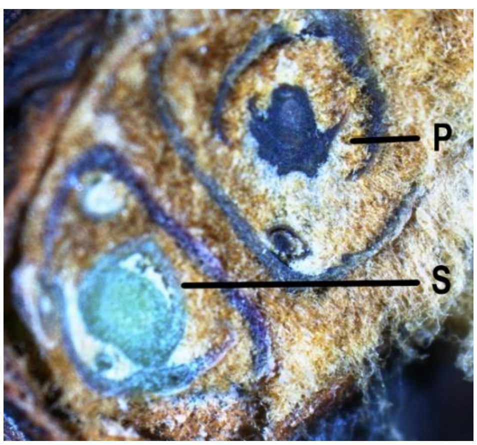

Figure 2. A cross-section of a 'Chardonnay' bud showing a blackened primary (P) bud that was lost in the deep freeze (top right) next to a still viable secondary (S) bud (bottom left).

The Feb. 15th deep freeze event was lethal to some buds at some sites. The KRDC Plant Physiology program also tracks bud viability in 12 of our 23 'bud hardiness' sites. The results of these efforts, broken down into vinifera and hybrid sites, can be found in Table 3. As expected, the more sensitive vinifera were harder hit than the hardier hybrids. Vinifera primary bud viability dropped by 19%, while the hybrids saw a decrease of only ≈ 6%. It is also expected that acute winter damage (i.e. a single night of deep cold) will disproportionately effect the more sensitive primary as opposed to the secondary buds (Martinson, 2011). The drop in secondary bud viability was < 3% in the vinifera relative to ≈ 2% in the hybrids (Table 3). The minimum temperatures, bud hardiness levels within a cultivar and the level of bud mortality observed across sites were all variable. When we examined the data on a site to site basis, we discovered our predicted bud hardiness levels were quite accurate. For example, most sites in the western Annapolis Valley experienced minimum temperatures of between -14 and -18 °C (just below predicted lethal levels); these sites did not experience meaningful bud mortality levels. In the eastern Annapolis Valley, most sites examined experienced lows of between -20 and -21 °C; the

Table 3. Primary and secondary bud viability % before and after the Feb. 15 low temp. event

	primary bud viability (%)	secondary bud viability (%)
Jan. 20: pre-deep-freeze		
vinifera (7 sites)	95.7%	84.2%
hybrids (5 sites)	94.1%	97.3%
Feb. 17: post-deep-freeze		
vinifera (7 sites)	77.7%	81.4%
hybrids (5 sites)	87.9%	95.0%

vinifera at these sites typically experienced bud mortality in the 5 to 15% range. However, unfortunately, there were also a few sites, both within and outside of our survey sites, that experienced temperatures of -24 to -26 °C; we are finding bud mortality of 50 to 95% in the vinifera at these sites, as predicted. At these lowest temperatures, potential vascular damage also becomes a concern. Even some hybrid cultivars (with the notable exception of 'Marquette') were found to have sustained damage in weak or compromised sites or in sites that experienced the deepest colds. The DTA proved to be accurate in predicting the hardiness levels of these more vulnerable sites too. For example, one 'L'Acadie' site was noticeably weak going into winter (excessive blind nodes and low vigour); its site-specific LTE10 and LTE50 values were -16 and -24 °C, respectively, which is below average for this cultivar. This site reached -21 °C during the Feb. 15 low temperature event and the canes lost 26% of their primary buds overnight, again, as predicted.

<u>Best practices</u>

It is important to assess your buds each year prior to pruning, even after winters without a significant cold temperature event. Higher bud mortality levels can also sometimes be observed as a result of chronic as opposed to acute bud damage (e.g. many 'Riesling' sites after the 2018 / 2019 winter). The best way to perform a bud viability assessment is to take a representative number of canes from each block and dissect, via cross-sectioning, and score all of the buds (Goffinet, 2004). Understanding your bud viability levels determines how the vine should best be pruned (Table 4). While impractical for larger growers, allowing for possible pruning adjustments in the wake of a damaging winter is also a reminder of why growers are encouraged, if possible, to delay pruning until March or April (or at least leave extra canes), after the majority of winter is behind them (Wamboldt et al., 2002).

Table 4. Wine grape bud mortality and recommended adjustment to pruning (Zabadal et al., 2007)

bud mortality	recommendation
< 15%	no adjustment
15 – 35%	retain 35% more buds
35 – 50%	retain 100% more buds
> 50%	minimal or no pruning

If you have any questions or comments, please feel free to reach out to the KRDC Plant Physiology Program using the contact information listed above. Funding for this work is through an AgriScience Program Cluster project (J-001930, ASC-12 Grape Wine Cluster Activity 7) and the Nova Scotia Department of Agriculture. This report, and others, can be found on the Canadian Grape Certification Network (CGCN) webpage: https://www.cgcn-rccv.ca/site/home .

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