BC FoodWeb

BRITISH COLUMBIA WINE GRAPE COUNCIL

Government research report

Grapevine Cold Hardiness: New Insights on Temperature and Exposure Time

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KEY TAKEAWAYS

Current research is improving our understanding of how grapevine buds respond to winter cold and why both temperature and exposure time matter.

- **Bud cold hardiness changes over the winter**. Buds become better able to handle cold as temperatures drop, then gradually lose some of that protection as spring approaches.
- **LTE values show how much cold the buds can handle before injury is expected**. A more negative LTE value means the buds can survive colder temperatures before damage occurs.
- **The length of a cold event matters**. Buds can still be damaged when temperatures stay very cold for many hours, even if they do not reach the usual critical temperature.
- Looking at both temperature and how long the cold lasts could improve future cold injury predictions and give growers a more accurate picture of bud risk.

How can this information be used

This factsheet summarizes current knowledge on grapevine cold hardiness and emerging research on how both temperature and the length of cold exposure can affect bud injury. It is intended to help BC grape growers better understand LTE values, seasonal changes in bud hardiness, and why minimum temperature alone may not always explain the level of damage observed in a vineyard.

The research is still ongoing, so the information presented here should be used as a guide rather than as a stand-alone prediction or management tool. As new data are collected, these findings may help improve future cold injury models and provide growers with a more complete picture of winter bud risk.

Production Type

- Wine grapes

Practice Benefit(s)

- Crop risk assessment
- Crop protection

Research Location

- Summerland, BC

Key Terms

- *Low-temperature exotherm values (LTE):* A negative temperature value that indicates when grapevine buds are expected to experience freezing injury.
- *Primary bud:* The main bud within a grapevine compound bud. It usually produces the strongest shoot and carries most of the potential crop.
- *Secondary bud:* A backup bud that can produce a shoot if the primary bud is damaged, although it generally has lower crop potential.

What is grapevine cold hardiness?

In January 2024, an extreme cold event swept across British Columbia's wine-growing regions, exposing vineyards to some of the lowest temperatures recorded in recent years. Many growers experienced widespread bud and vine damage, with some vineyards suffering severe crop losses that affected not only the 2024 season but also future wine production. The event highlighted how vulnerable grapevines can be to extreme temperature conditions and reinforced the importance of understanding and predicting winter injury.



Figure 1. Snow-covered grapevines during winter in British Columbia. Photo from Westside Wine Trail

Winter injury, also called **cold injury**, occurs when freezing temperatures damage grapevine tissues like buds, canes, cordons, or trunks (Figure 2). The severity of damage can range from little or no visible injury to reduced yields, poor vine growth, or vine death in extreme cases. Reaching a certain temperature does not necessarily mean injury will occur. The risk depends on factors, including the grape variety and weather conditions before and during the freezing event. Cold hardiness is also influenced by several vineyard and vine factors, including vine vigor, soil moisture, nutrition, pests and diseases, rootstock, training system, and bud exposure to sunlight.

Grapevines naturally prepare for winter by developing **cold hardiness,** which is their ability to survive freezing temperatures by making changes that help protect the living tissues inside their buds from freezing damage. Cold hardiness increases as vines acclimate to cooler conditions in the fall and is maintained through much of the winter. Cold hardiness gradually declines as temperatures warm before spring. Because cold hardiness changes throughout the dormant season (late fall to early spring), the same cold temperature can result in very different levels of freezing damage, depending on when the cold temperature occurs. Understanding these seasonal changes is the basis of how cold injury risk is assessed in BC vineyards.

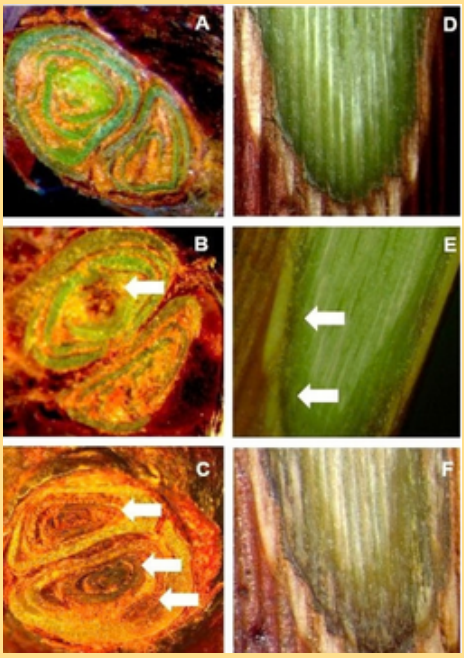




Figure 2. Cold injury in grapevine buds and canes.

Left: Buds and cane tissue have been cut open to show the internal tissues. (A) healthy compound bud; (B) cold injury to the primary bud; (C) more severe injury affecting the primary, secondary, and tertiary buds; (D) healthy cane tissue; (E) moderate cold injury to cane tissue; and (F) more advanced cane injury. Photo: Paolo Sabbatini, Michigan State University Extension. Ag and Natural Resources College.

Right: Bark has been cut away to reveal the internal cane tissue. The left cane shows healthy green tissue, while the right cane shows winter injury and brown, damaged tissue. Photo: John Strang, University of Kentucky.

How do we currently predict cold hardiness?

Unlike diseases or insect damage, the risk of cold injury cannot be assessed simply by looking at a vineyard. This makes predicting cold injury more complex than simply monitoring the weather forecast.

In British Columbia's Okanagan Valley, cold hardiness has been monitored for more than a decade to track how grapevine buds are responding to winter conditions. Cold hardiness is measured by identifying the temperature at which buds are expected to suffer freezing injury. The results are reported as low temperature exotherm (LTE) values. For example, a LTE_{50} of –22°C is the temperature at which about 50% of the buds are expected to die. LTE_{10} represents the temperature expected to cause 10% bud death, while LTE_{90} represents the temperature expected to cause 90% bud death. A lower, more negative LTE value means the buds are more cold hardy because they can withstand colder temperatures before freezing injury occurs.

These measurements are shared through seasonal **Grape Bud Hardiness Reports** and, together with weather data, are used to estimate cold injury risk throughout the dormant season. These tools have greatly improved our understanding of cold injury; however, LTE values mainly describe the temperature at which injury is expected and may not fully account for how long buds remain exposed to cold conditions.

Can we improve cold hardiness prediction?

Current cold hardiness measurements have greatly improved our ability to estimate vines' risk to cold injury, but recent losses from extreme cold events in BC show that there is still lots of room for improvement. Researchers are interested in how factors aside from minimum temperature contribute to cold injury, such as duration of cold exposure. Researchers are asking: Could exposure to **–18°C for 24 hours** result in similar bud damage as exposure to **–22°C for only a few hours?** The answers to these questions may improve cold hardiness models that provide growers with more information on predicting damaging winter conditions.

What are we learning?

To determine whether the duration of cold exposure influences cold injury, researchers at Agriculture and Agri-Food Canada are exposing dormant Merlot buds to a range of freezing temperatures for different lengths of time under controlled conditions. The goal is to understand whether combining **temperature** and **exposure duration** can improve winter injury prediction beyond what is currently possible using temperature alone.

Results to date suggest that the **length of a cold event matters**. In the initial study, primary buds were damaged within **24 hours at holding temperatures of -14°C, -16°C, -18°C and -20°C**, while secondary buds generally required longer exposure before injury occurred at the same temperature (Figure 3). A follow-up study expanded the temperature range from **-11°C to -22°C** and found that bud survival continued to decline as temperature decreased and exposure time increased (Figure 4). These findings suggest that both the severity and duration of freezing conditions influence grapevine bud survival.

Building on these results, researchers are now exploring ways to incorporate exposure duration into future winter injury prediction models for winegrapes. Rather than estimating injury from a single temperature threshold, the long-term goal is to develop a probability-based approach that accounts for both **how cold** a freezing event becomes and **how long** vines remain exposed to those conditions. This work is ongoing, and additional research will help determine how these findings can be incorporated into future prediction tools for grape growers.

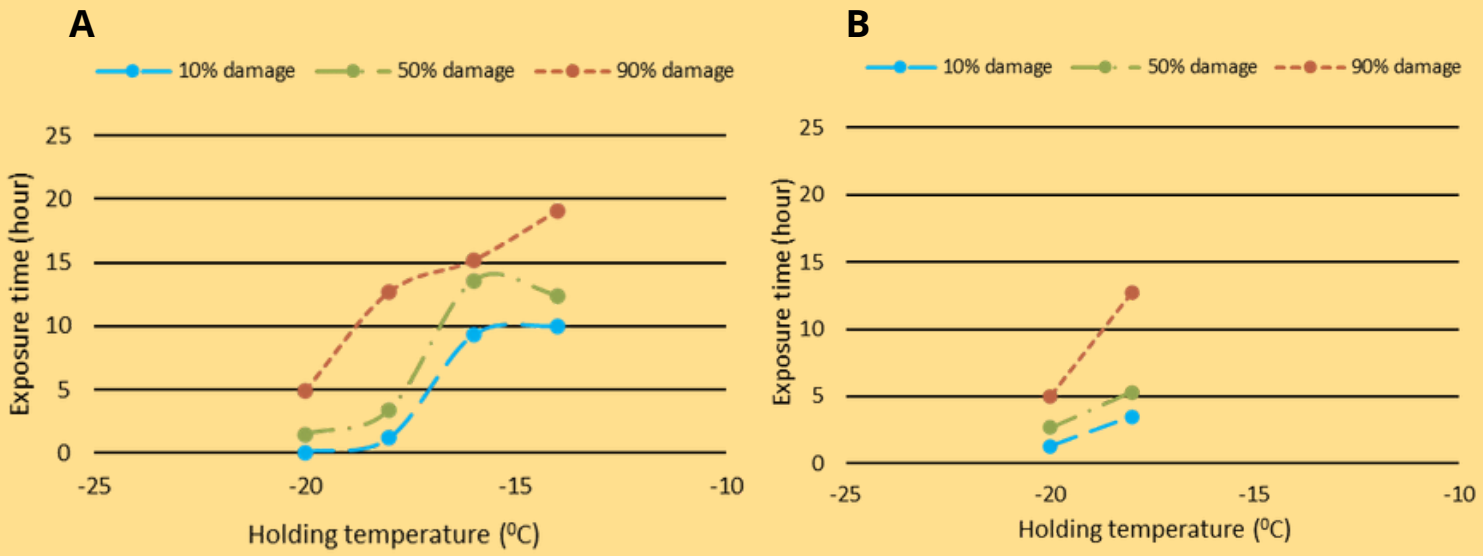
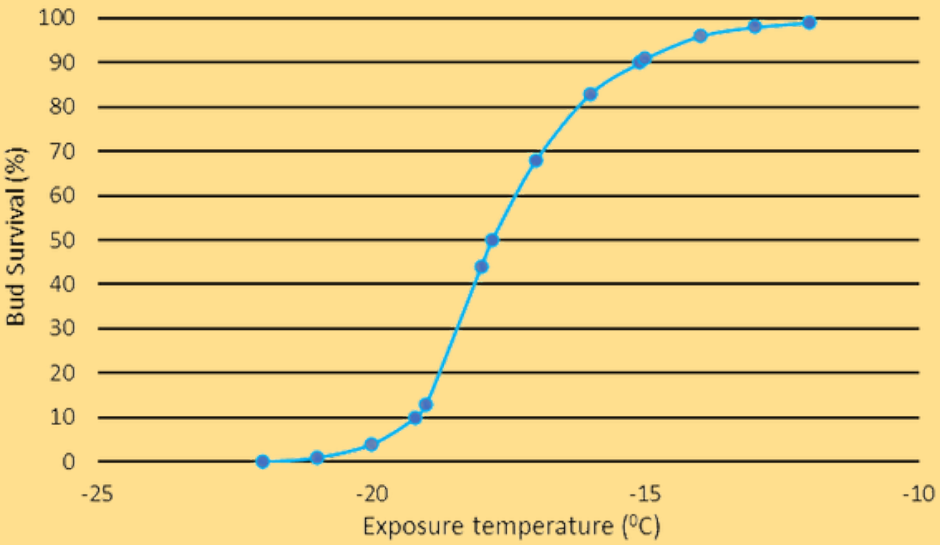


Figure 3. Effect of temperature and exposure time on primary and secondary grapevine bud damage. Buds were exposed to constant temperatures of −14°C, −16°C, −18°C, and −20°C.
(A) Primary buds required less time to reach 10%, 50%, and 90% damage as temperatures became colder. At warmer temperatures, buds needed to remain exposed for longer before similar levels of injury occurred. **(B)** Secondary buds showed the same general pattern but required longer exposure before damage occurred. Under the tested conditions, no secondary bud damage was observed within 24 hours at temperatures of −16°C and -14°C.



Figurue 4. Survival of Merlot buds after 24 hours of exposure to constant temperatures. Bud survival decreased as exposure temperatures became colder, with survival dropping rapidly at lower temperatures.

What could this mean for BC growers?

This research could improve winter injury prediction by showing how temperature and exposure duration work together to affect bud survival. More complete prediction tools could help BC grape growers better judge the risk of bud injury, interpret cold-hardiness reports, and make more informed decisions before and after extreme cold events. For example, growers may be better able to identify when a long period of moderately cold weather could be as damaging as a shorter period of more severe cold.

What's next?

The next phase of this research will focus on collecting additional data to confirm the relationships observed between temperature, exposure duration, and bud injury. These findings will be used to develop and validate a damage estimation model that can be incorporated into future cold hardiness prediction tools, helping improve cold injury risk assessment for grape growers in BC.

To learn more about grapevine cold hardiness watch the BC Wine Grape Council's "Cold Hardiness: Dealing with Winter Damage" webinar.

About this factsheet

This research summary was prepared by Yussuf Adedeji from the BC Food Web team, with the help of Ben-min Chang and Kirsten Hannam and is based on the following research reports and resources:

- Chang, B.-M., Estergaard, B., & Marsh, S. (2024). *Warmer but longer cold exposure can hurt*. American Society for Enology and Viticulture National Conference.
- Chang, B.-M., Estergaard, B., & Marsh, S. (2025). *Cold damage might be a game of probability.* American Society for Enology and Viticulture National Conference.

Want to learn more?
For any questions regarding this research, contact Ben-Min Chang at ben-min.chang@agr.gc.ca

For more research briefs like this one, visit bcfoodweb.ca/research-briefs.

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