Activity 5
Assessing Grapevine Cold Hardiness Under Climatic Conditions of Eastern Canada by Applying Various Techniques

CGCN-RCCV Webinar

March 27, 2025

Andréanne Hébert-Haché and Caroline Provost

CRAM
CENTRE DE RECHERCHE AGROALIMENTAIRE DE MIRABEL

Solutions for grape growing in cold regions

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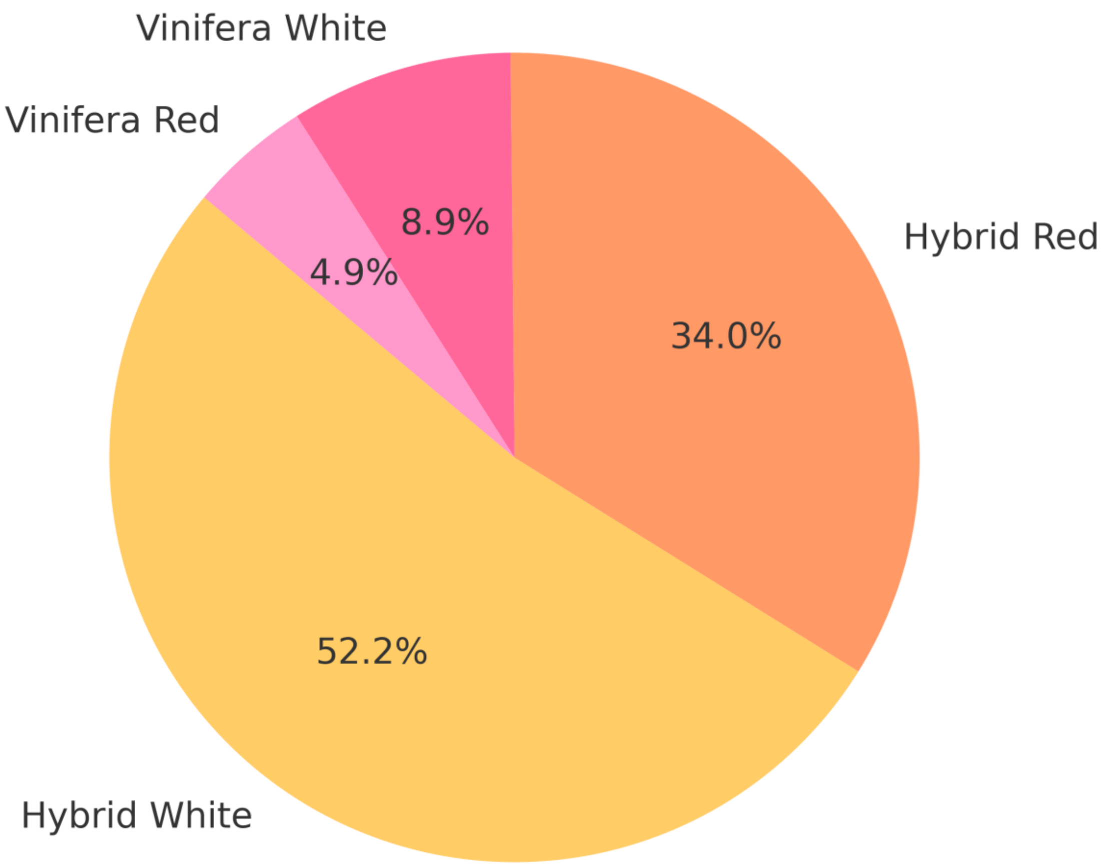
AGROALIMENTAIRE DE MIRABEL

Research at CRAM

- Centre de recherche agroalimentaire de Mirabel
- Three areas of research
  - Oenology and viticulture
  - Crop protection in greenhouses
  - Entomology of small fruit crops
- 2 hectares research vineyard (approx 5 acres)
  - New cultivar trial
  - Grafting study
  - Potassium accumulation study
  - Geotextile trials
  - UV technology tests
  - New spring frost protection methods
  - Cover crop study

Grape growing in Québec

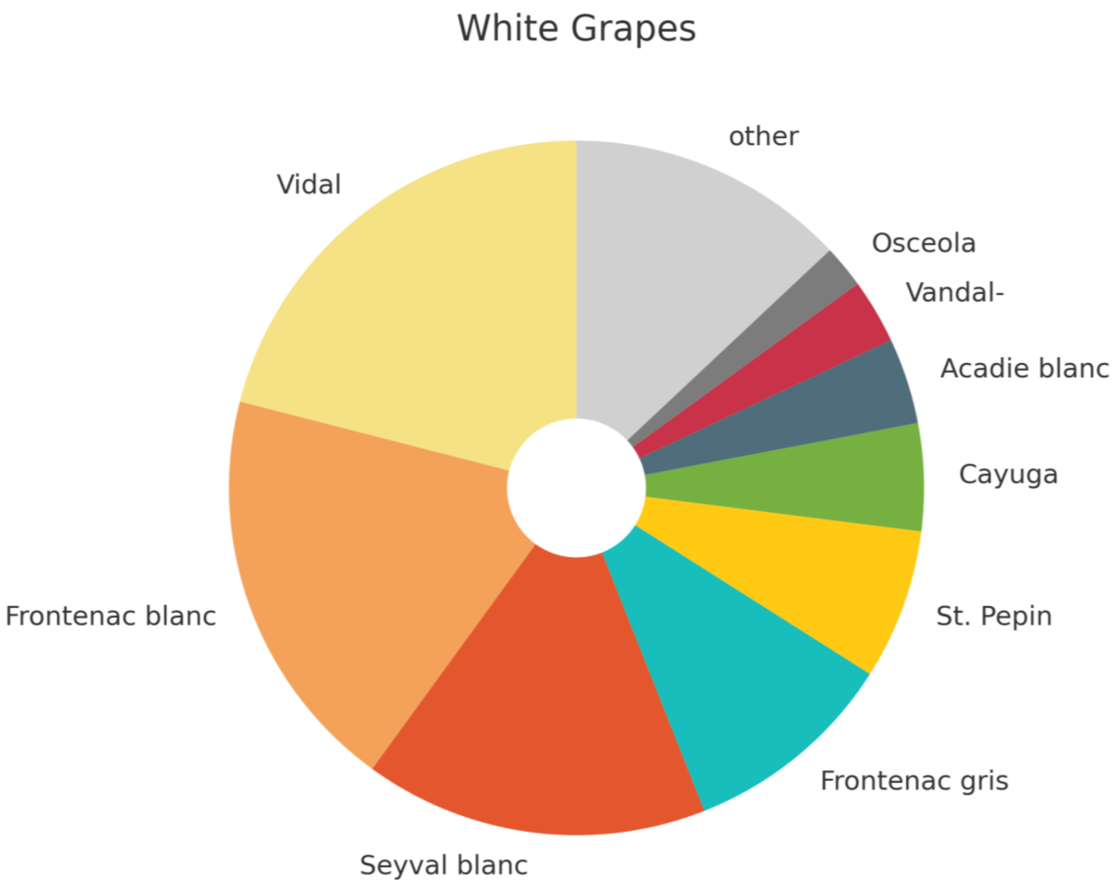


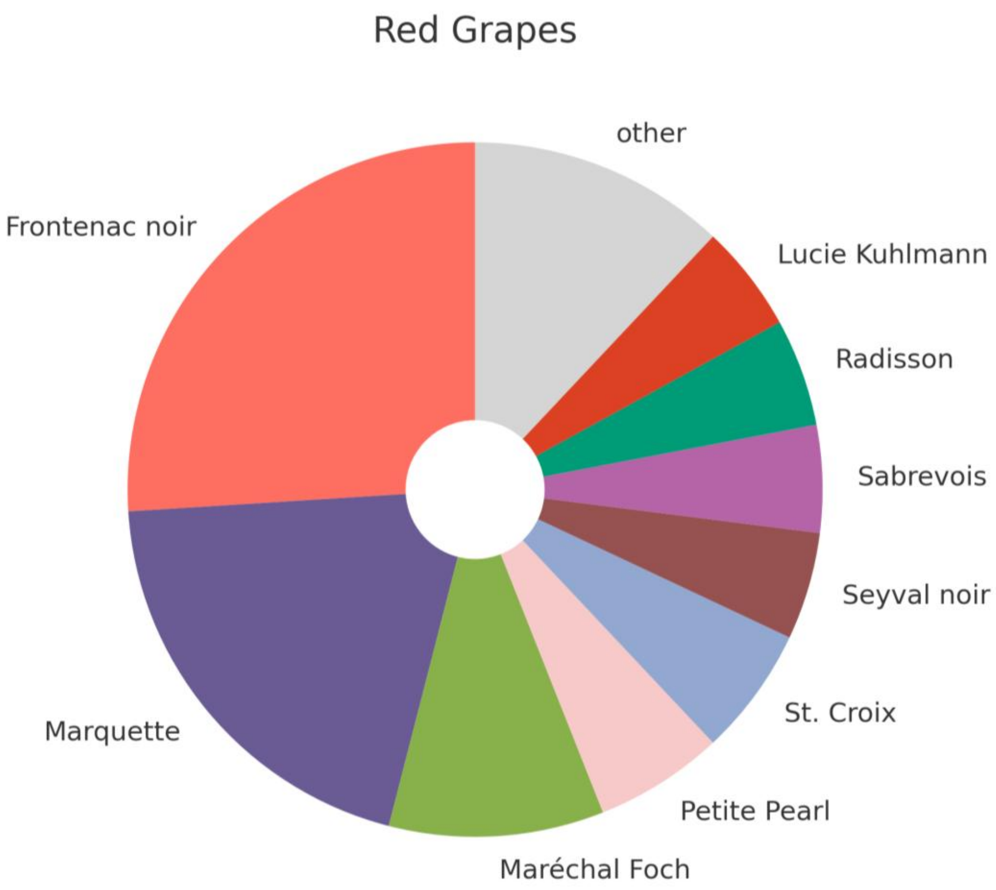
« Young » industry

1200 hectares under vine

180 vineyards

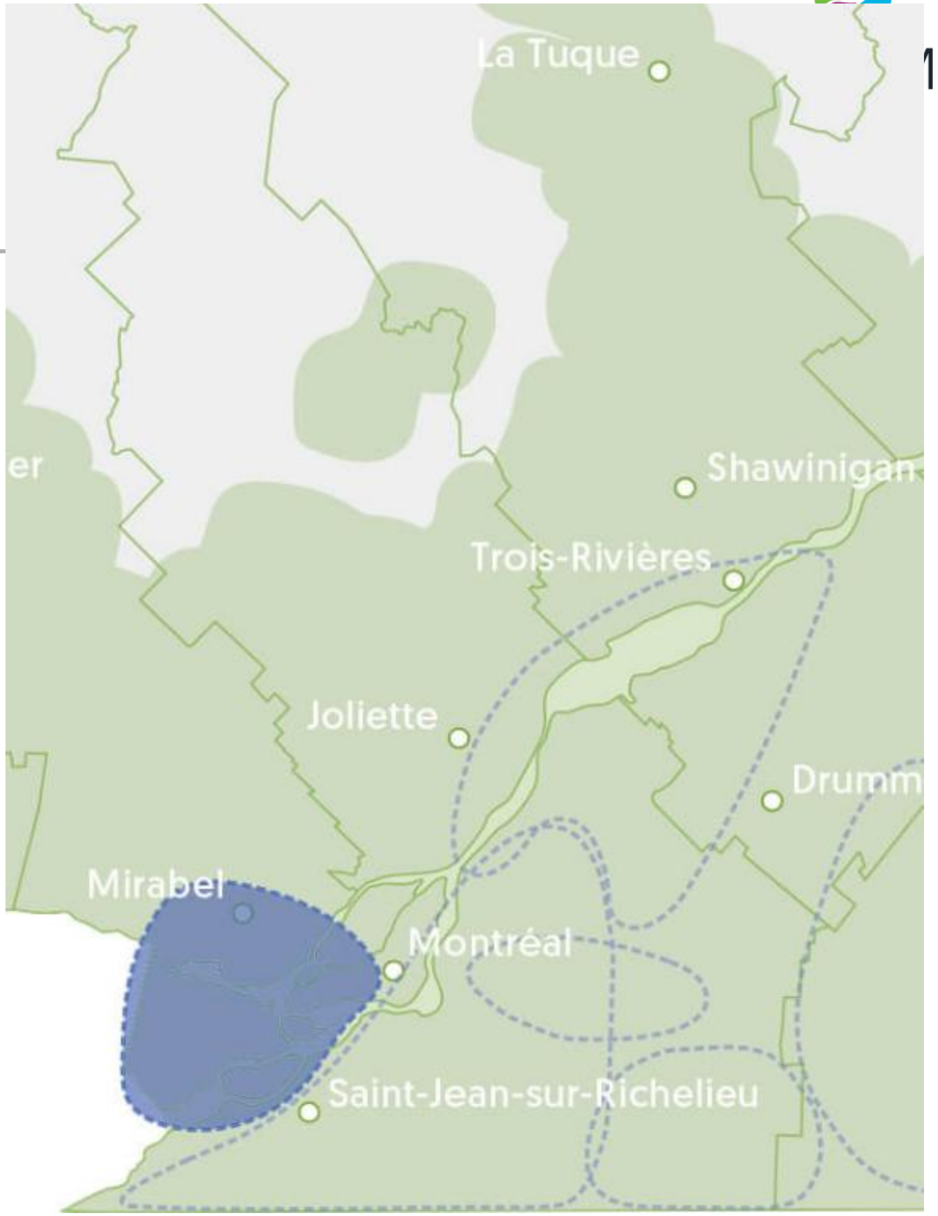
Hybrid cultivars

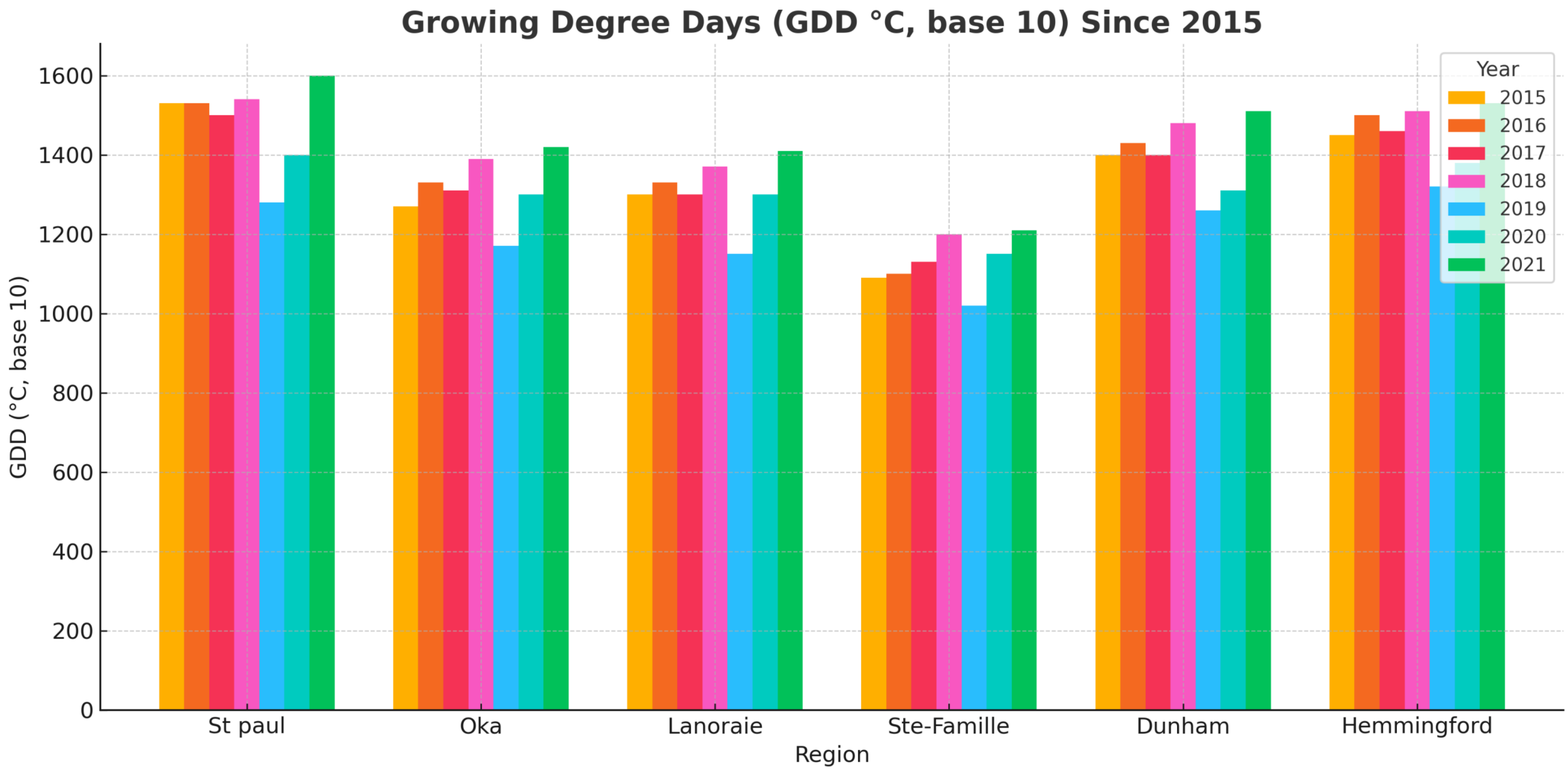




Regions and weather

- Between 500 and 900 mm of rain
- Humidity
- Temperatures below -30°C in the winter
- 15 to 60 cm of snow on the ground typically between end of December and March
- Bud break early to mid May, harvest September - October





Growing Degree Days (GDD °C, base 10) Since 2015
GDD (°C, base 10)
0
200
400
600
800
1000
1200
1400
1600
Year
2015
2016
2017
2018
2019
2020
2021
St paul
Oka
Lanoraie
Ste-Famille
Dunham
Hemmingford
Region

Activity 5

Part 5a
Monitoring system for evaluation of cold hardiness of several grapevine cultivars under climatic condition of Eastern Canada.

Part 5b
Use of winter protection systems to reduce winter injuries of cold sensitive cultivars.

Part 5c
Use of rootstocks to improve cold hardiness of hybrid cultivars.

Activity 5

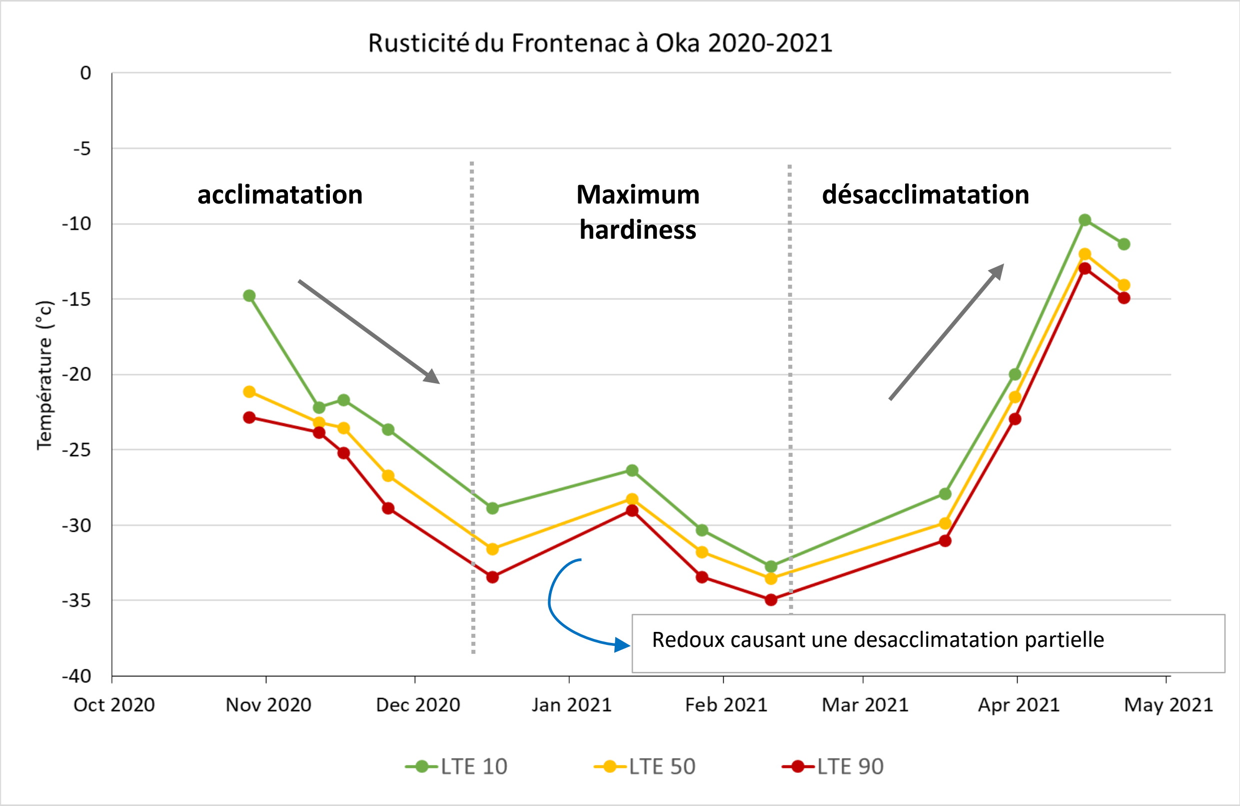
Part 5a
Monitoring system for evaluation of cold hardiness of several grapevine cultivars under climatic condition of Eastern Canada.

Establishment of a monitoring system for cold hardiness (LTE 10, 50, 90)

Development of models for the cold hardiness

5a: background

- Cold hardiness is dynamic
- Factors that impact vine health will generally have an impact on cold hardiness
- Set of physiological, structural and biochemical changes that increase vine tolerance to cold temperature
- Without geotextile, cold temperatures significantly limit the choice of cultivar



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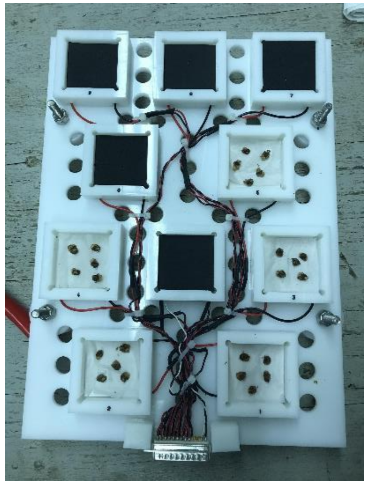
Variety	Vigor	Cold hardiness	References
Red			
Baltica	moderate	-29°C to -34°C	1, 2
Concord	high	-26°C to -32°C	4, 5
De Chaunac	moderate/high	-26°C to -32°C	1, 4
Frontenac	high	-29°C to -34°C	1, 2, 3, 4
Léon Millot	high	-26°C to -32°C	1, 3, 4, 5
Marechal Foch	moderate	-26°C to -32°C	1, 3, 4, 5
Marquette	high	-29°C to -34°C	1, 3
Petite Perle	moderate	-29°C to -34°C	1, 3
Sabrevois	moderate	-29°C to -34°C	1, 3
Skandia	moderate	-29°C to -34°C	1, 2, 3
White			
St. Croix	moderate/high	-29°C to -34°C	1, 2, 3, 5
Frontenac blanc	high	-29°C to -34°C	1, 2, 3
Frontenac gris	high	-29°C to -34°C	1 , 2, 3
La Crescent	high	-29°C to -34°C	1, 2, 3
Louise Swenson	low	-29°C to -34°C	1, 2, 3
Seyval	moderate	-23°C to -29°C	1, 3, 4, 5
St.Pepin	moderate	-29°C to -34°C	1, 3, 5
Traminette	moderate/high	-23°C to -29°C	1, 4
Vandal Cliche	moderate/high	-26°C to -32°C	1
Vidal	moderate	-20°C to -26°C	1, 4, 5

5a: methodology

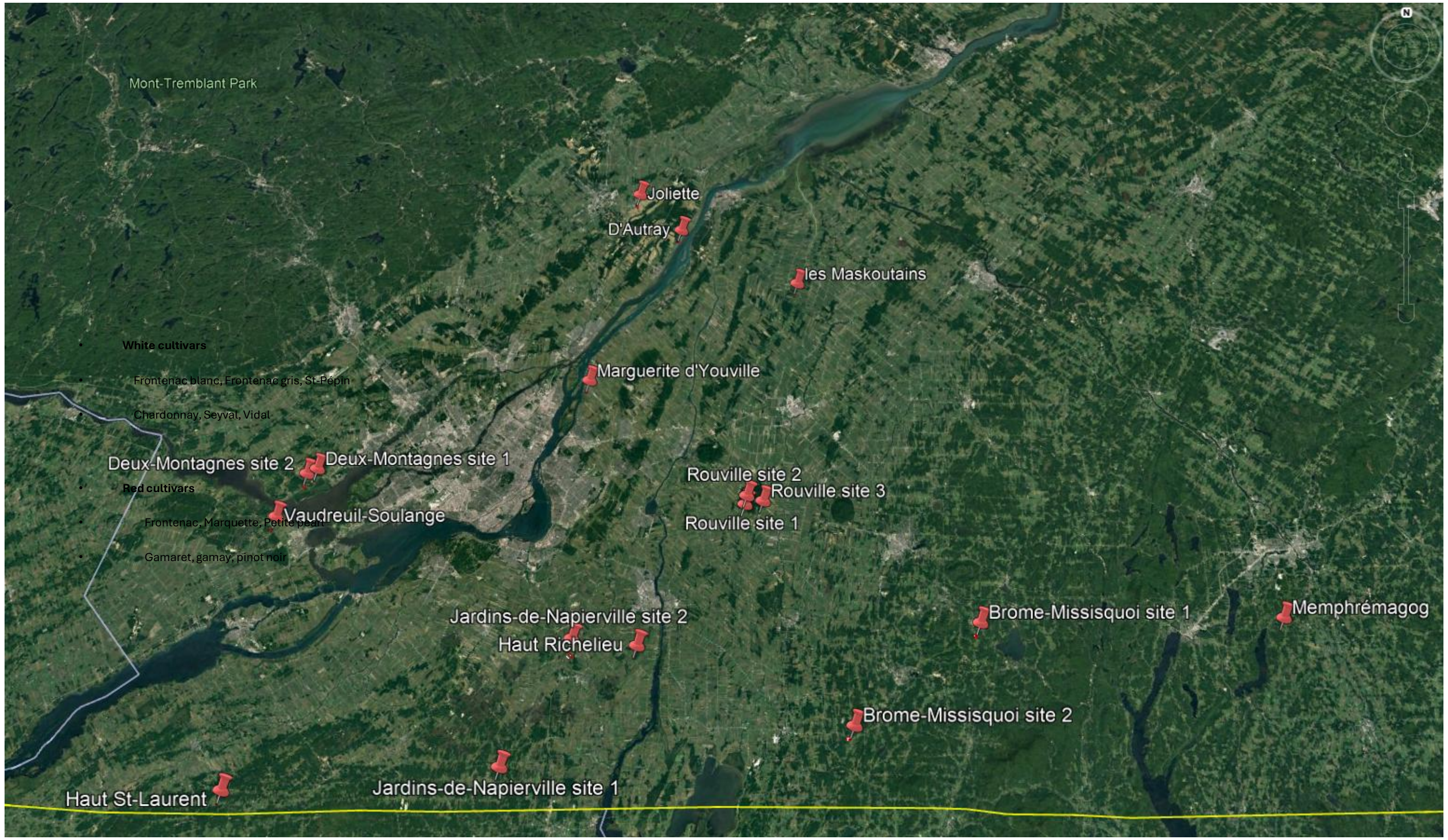
VineAlert

CRAM

- Replication and frequency of sampling:
  - Year 1 and 2: 4 to 5 vines randomly sampled in vineyard, one cane/vine, bud 3-7 (20 to 25 buds)
  - Year 3: 9 vines, same bud position (45 buds)
  - Biweekly sampling from October to April since 2019
- Cold hardiness evaluation by differential thermal analysis (DTA; Mills et al 2006, Willwerth et al. 2014)
  - Bud survival, yield, pruning weights
- Data analysis performed with CCOVI software
  - LT10, 50 and 90 is communicated to growers every 1 to 3 weeks
- Weather monitored on site with data logger

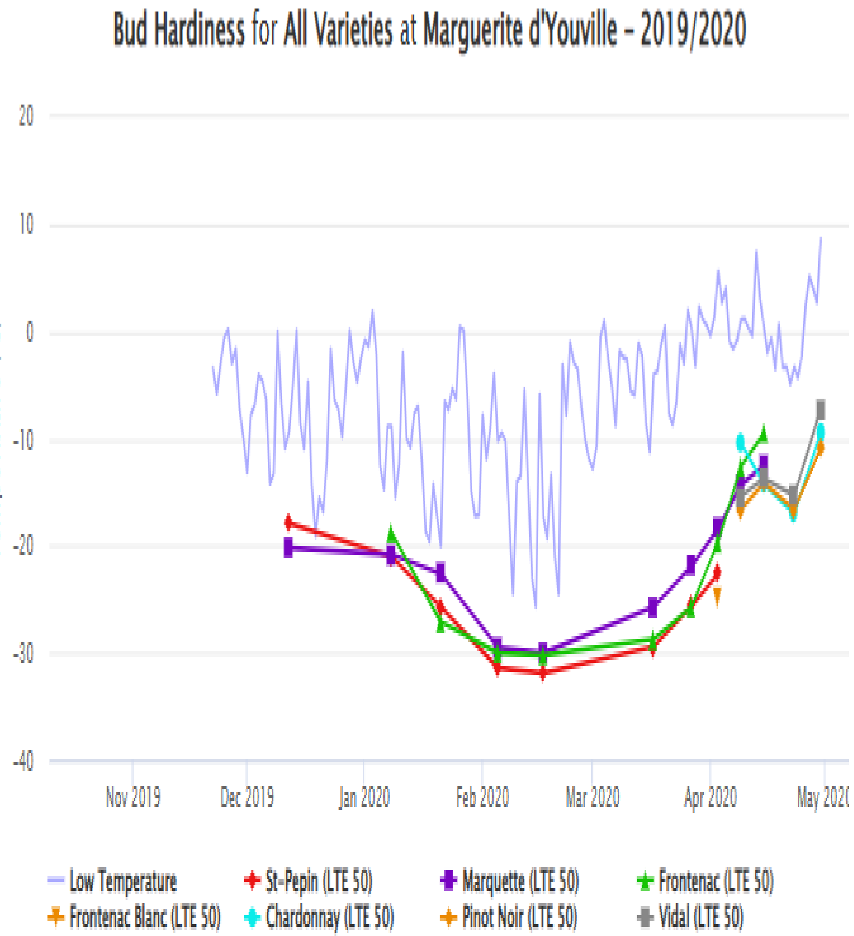


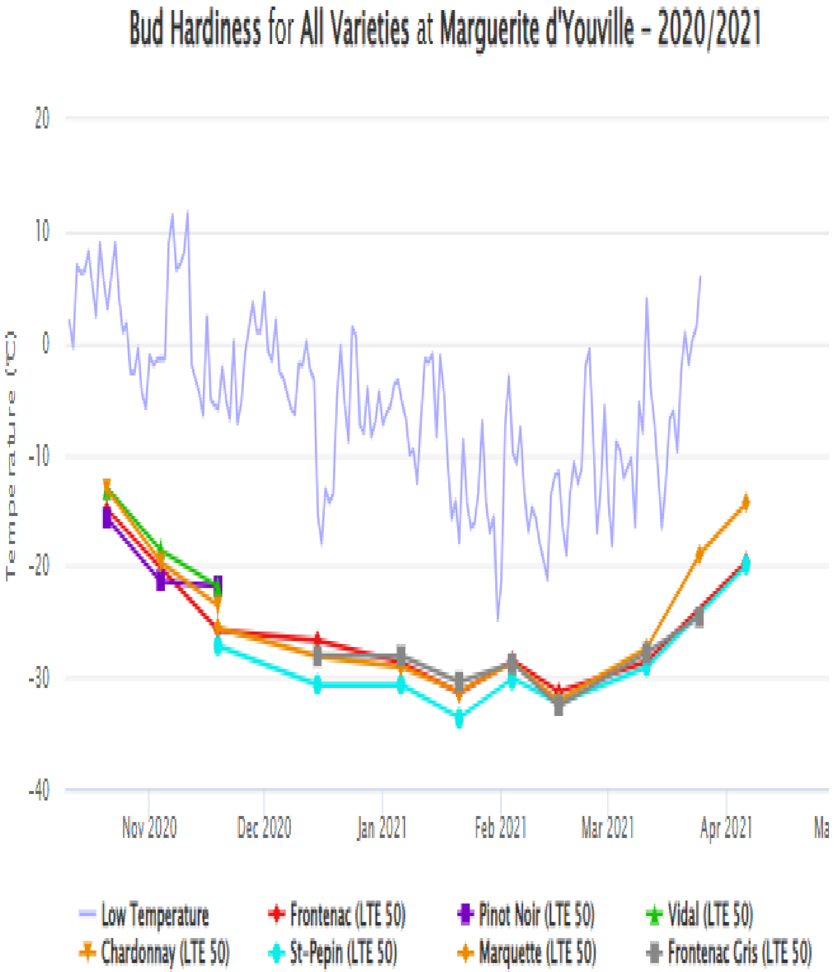
5a: cultivars and sites

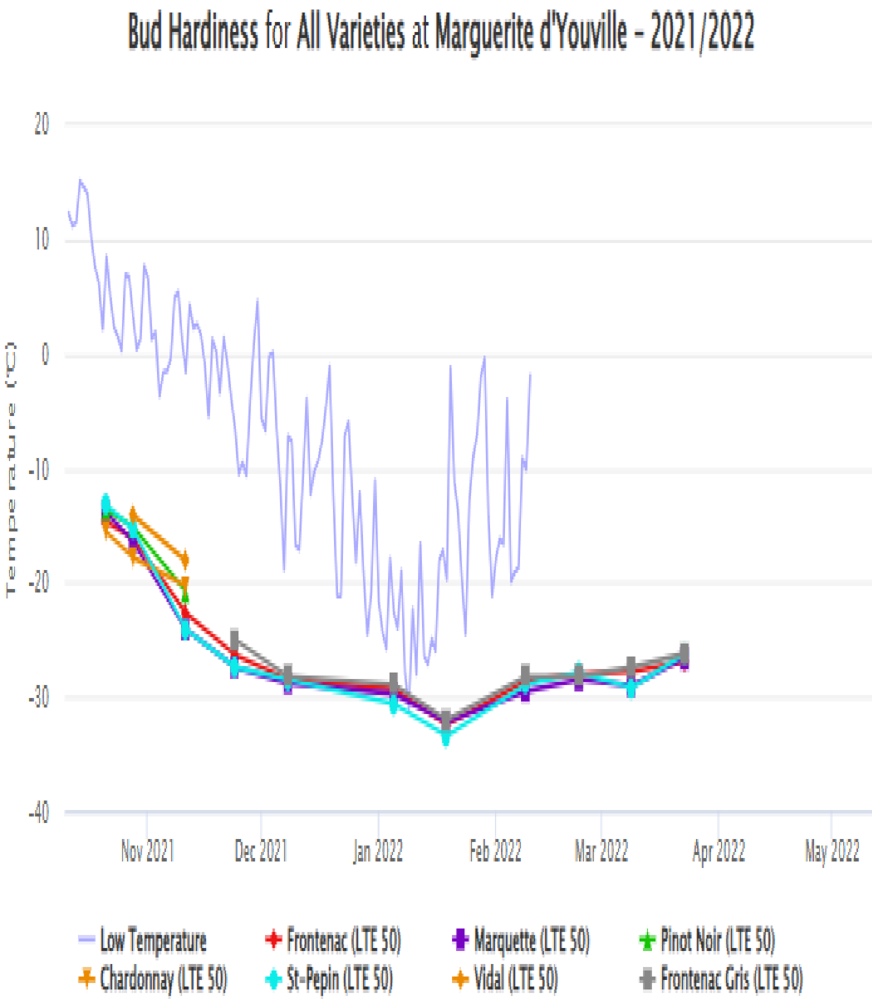


- **White cultivars**
  - Frontenac blanc, Frontenac gris, St-Pépin
  - Chardonnay, Seyval, Vidal
- **Red cultivars**
  - Frontenac, Marquette, Petite pearl
  - Gamaret, gamay, pinot noir

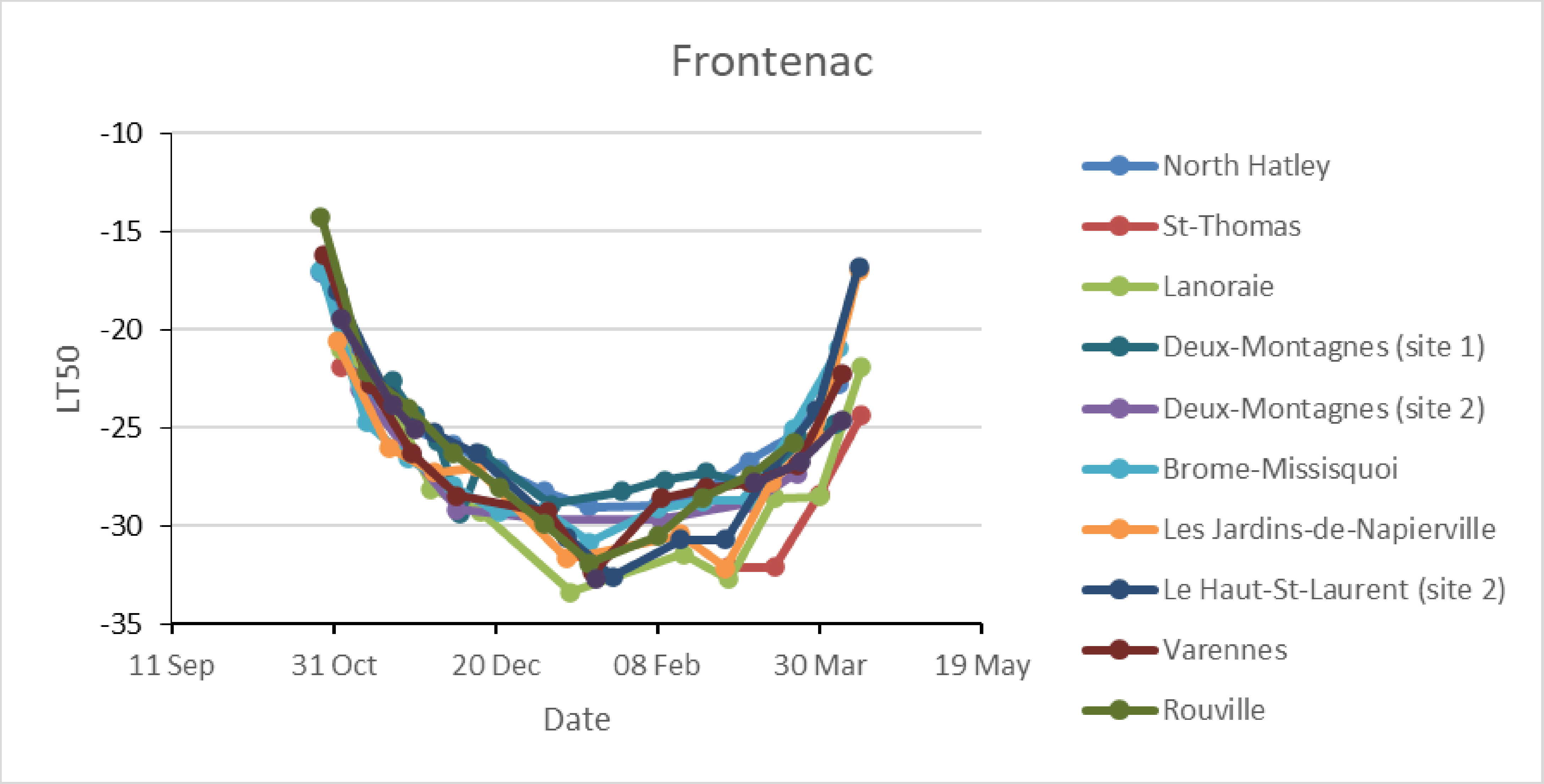
Results


Bud Hardiness for All Varieties at Marguerite d'Youville - 2019/2020
20
10
0
-10
-20
-30
-40
Nov 2019
Dec 2019
Jan 2020
Feb 2020
Mar 2020
Apr 2020
Low Temperature
St-Pepin (LTE 50)
Marquette (LTE 50)
Frontenac (LTE 50)
Frontenac Blanc (LTE 50)
Chardonnay (LTE 50)
Pinot Noir (LTE 50)
Vidal (LTE 50)

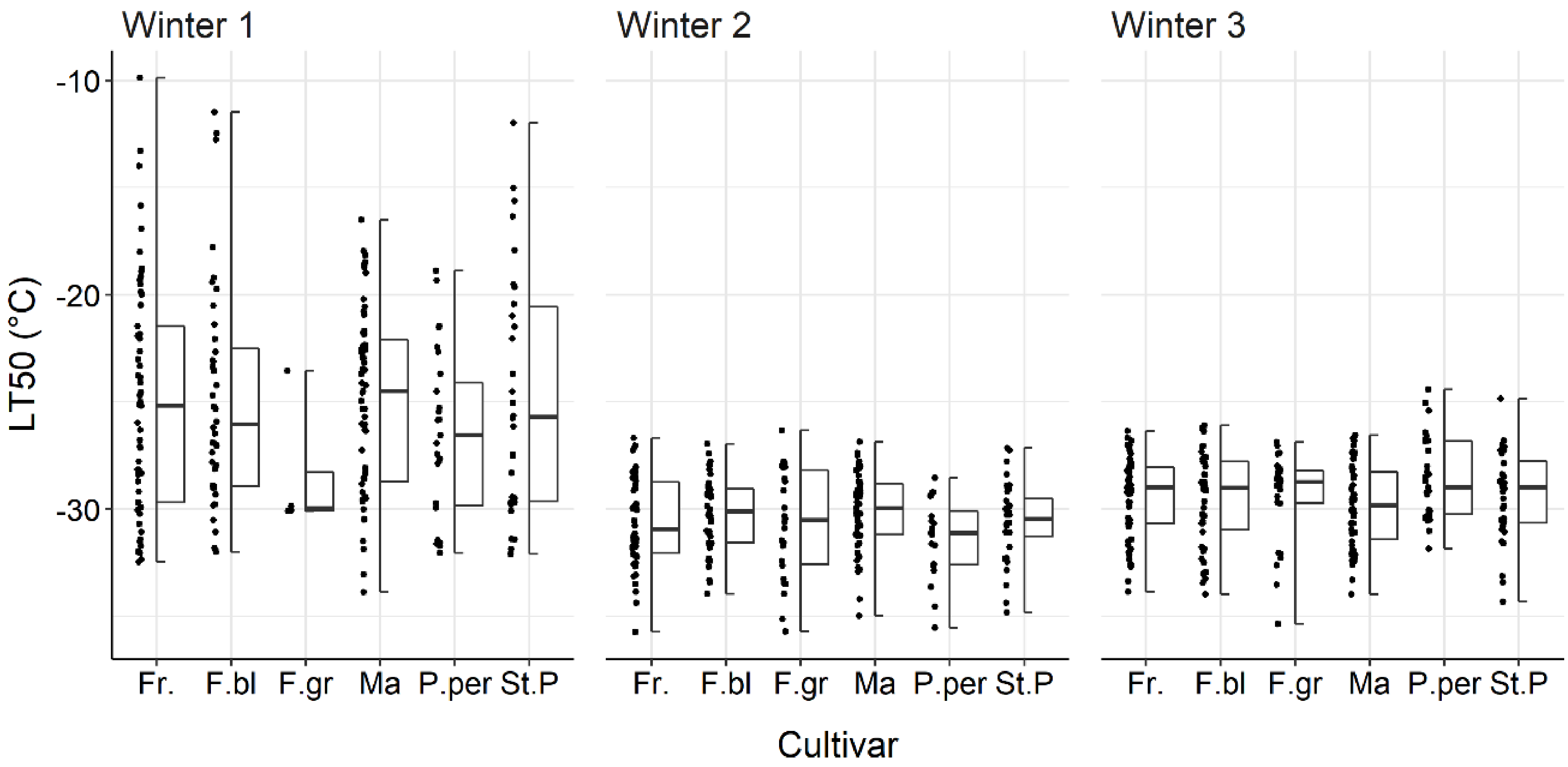

Bud Hardiness for All Varieties at Marguerite d'Youville - 2020/2021
Temperature (°C)
20
10
0
-10
-20
-30
-40
Nov 2020
Dec 2020
Jan 2021
Feb 2021
Mar 2021
Apr 2021
Low Temperature
Frontenac (LTE 50)
Pinot Noir (LTE 50)
Vidal (LTE 50)
Chardonnay (LTE 50)
St-Pepin (LTE 50)
Marquette (LTE 50)
Frontenac Gris (LTE 50)


Bud Hardiness for All Varieties at Marguerite d'Youville - 2021/2022
Temperature (°C)
20
10
0
-10
-20
-30
-40
Nov 2021
Dec 2021
Jan 2022
Feb 2022
Mar 2022
Apr 2022
May 2022
Low Temperature
Frontenac (LTE 50)
Marquette (LTE 50)
Pinot Noir (LTE 50)
Chardonnay (LTE 50)
St-Pepin (LTE 50)
Vidal (LTE 50)
Frontenac Gris (LTE 50)

Results


Frontenac
-10
-15
-20
-25
-30
-35
LT50
11 Sep
31 Oct
20 Dec
08 Feb
30 Mar
19 May
Date
North Hatley
St-Thomas
Lanoraie
Deux-Montagnes (site 1)
Deux-Montagnes (site 2)
Brome-Missisquoi
Les Jardins-de-Napierville
Le Haut-St-Laurent (site 2)
Varennes
Rouville

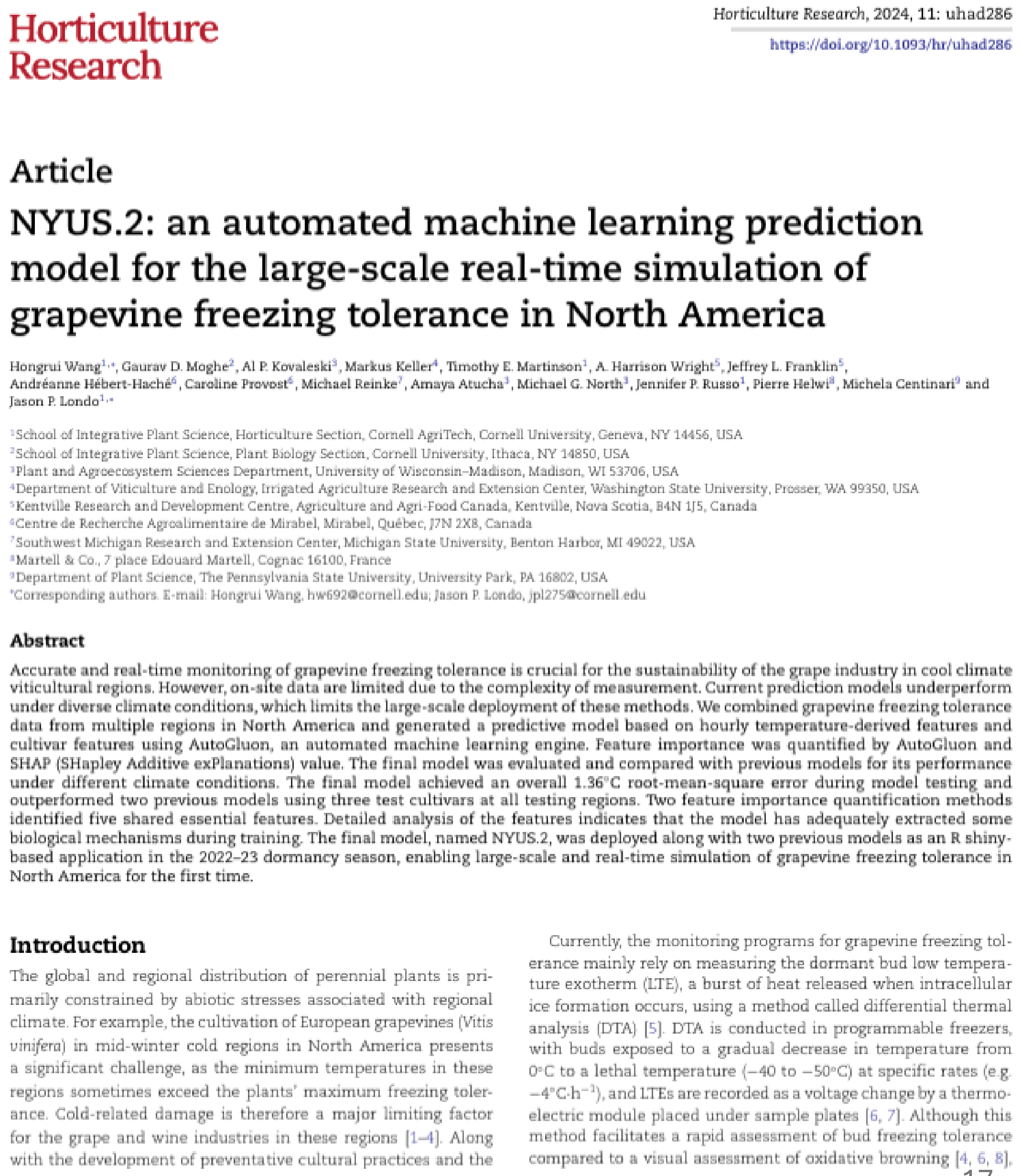
Results



Winter 1
Winter 2
Winter 3
LT50 (°C)
-10
-20
-30
Fr.
F.bl
F.gr
Ma
P.per
St.P
Cultivar

Modeling efforts

- Shared data with Drs. Wang and Londo at Cornell for inclusion in NYUS.2
- Cold hardiness prediction available online
- https://cornell-tree-fruit-physiology.shinyapps.io/North_America_Grape_Freezing_Tolerance/



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Article

NYUS.2: an automated machine learning prediction model for the large-scale real-time simulation of grapevine freezing tolerance in North America

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Abstract

Accurate and real-time monitoring of grapevine freezing tolerance is crucial for the sustainability of the grape industry in cool climate viticultural regions. However, on-site data are limited due to the complexity of measurement. Current prediction models underperform under diverse climate conditions, which limits the large-scale deployment of these methods. We combined grapevine freezing tolerance data from multiple regions in North America and generated a predictive model based on hourly temperature-derived features and cultivar features using AutoGluon, an automated machine learning engine. Feature importance was quantified by AutoGluon and SHAP (SHapley Additive exPlanations) value. The final model was evaluated and compared with previous models for its performance under different climate conditions. The final model achieved an overall 1.36°C root-mean-square error during model testing and outperformed two previous models using three test cultivars at all testing regions. Two feature importance quantification methods identified five shared essential features. Detailed analysis of the features indicates that the model has adequately extracted some biological mechanisms during training. The final model, named NYUS.2, was deployed along with two previous models as an R shiny-based application in the 2022–23 dormancy season, enabling large-scale and real-time simulation of grapevine freezing tolerance in North America for the first time.

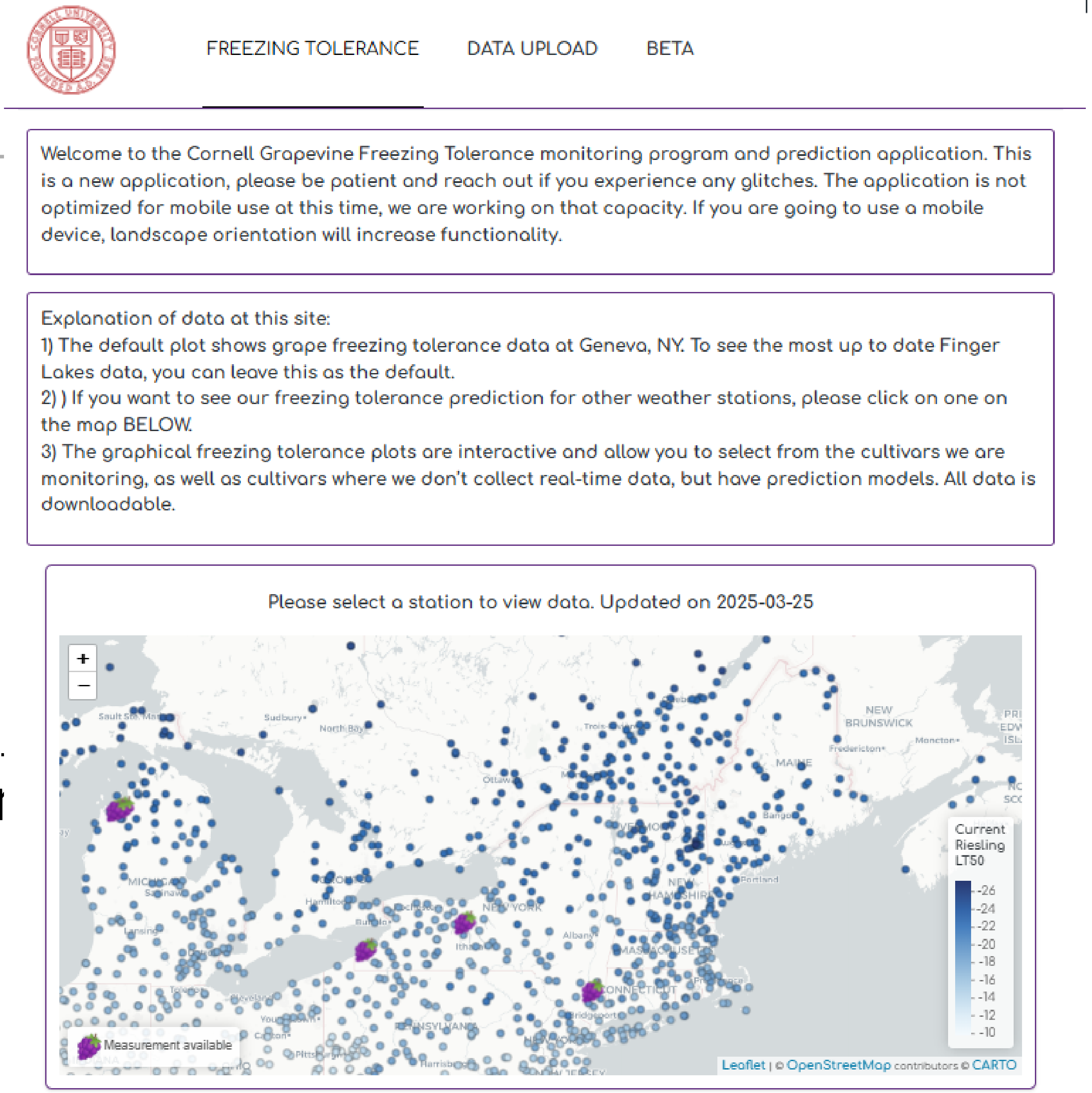
Introduction

The global and regional distribution of perennial plants is primarily constrained by abiotic stresses associated with regional climate. For example, the cultivation of European grapevines (*Vitis vinifera*) in mid-winter cold regions in North America presents a significant challenge, as the minimum temperatures in these regions sometimes exceed the plants' maximum freezing tolerance. Cold-related damage is therefore a major limiting factor for the grape and wine industries in these regions [1–4]. Along with the development of preventative cultural practices and the

Currently, the monitoring programs for grapevine freezing tolerance mainly rely on measuring the dormant bud low temperature exotherm (LTE), a burst of heat released when intracellular ice formation occurs, using a method called differential thermal analysis (DTA) [5]. DTA is conducted in programmable freezers, with buds exposed to a gradual decrease in temperature from 0°C to a lethal temperature (−40 to −50°C) at specific rates (e.g. −4°C·h^{-1}), and LTEs are recorded as a voltage change by a thermoelectric module placed under sample plates [6, 7]. Although this method facilitates a rapid assessment of bud freezing tolerance compared to a visual assessment of oxidative browning [4, 6, 8].

Modeling efforts

- Shared data with Drs. Wang and Londo at Cornell for inclusion in NYUS.2
- Cold hardiness prediction available online
- https://cornell-tree-fruit-physiology.shinyapps.io/North_America_Grape_Freezing_Tolerance/



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5a: Conclusions

VineAlert

- Outcomes
  - We have built a bud hardiness monitoring system for the Quebec industry
  - Published 24 newsletters so far over three years
  - Now on VineAlert and the Cornell Grapevine Freezing Tolerance website
- Observations and conclusions
  - Site and annual differences are important and we need to keep monitoring if we want a robust model
  - Maximum hardiness of the hybrids is attained and being documented
    - Differences not confirmed yet
  - Hardiness of *Vitis vinifera* similar to hybrid until geotextile are installed

Activity 5

Part 5a
Monitoring system for evaluation of cold hardiness of several grapevine cultivars under climatic condition of Eastern Canada.

Part 5b
Use of winter protection systems to reduce winter injuries of cold sensitive cultivars.

Part 5c
Use of rootstocks to improve cold hardiness of hybrid cultivars.

Activity 5

Knowledge acquisition on winter protection systems with geotextile

Part 5b
Use of winter protection systems to reduce winter injuries of cold sensitive cultivars.

Development of an optimal use guidelines on timing of installation and removal and types of geotextile

5b: geotextile technology

- Approx. 95% of covered vines are covered with geotextiles (as reported to Conseil des vins du Québec)
- We cover all *V. vinifera*…. And a lot of hybrids
  - Vidal, Seyval, Maréchal Foch, Lucy Khulmann, New York Muscat, Acadie….
- **Technical and logistical challenge**

5b: geotextile technology

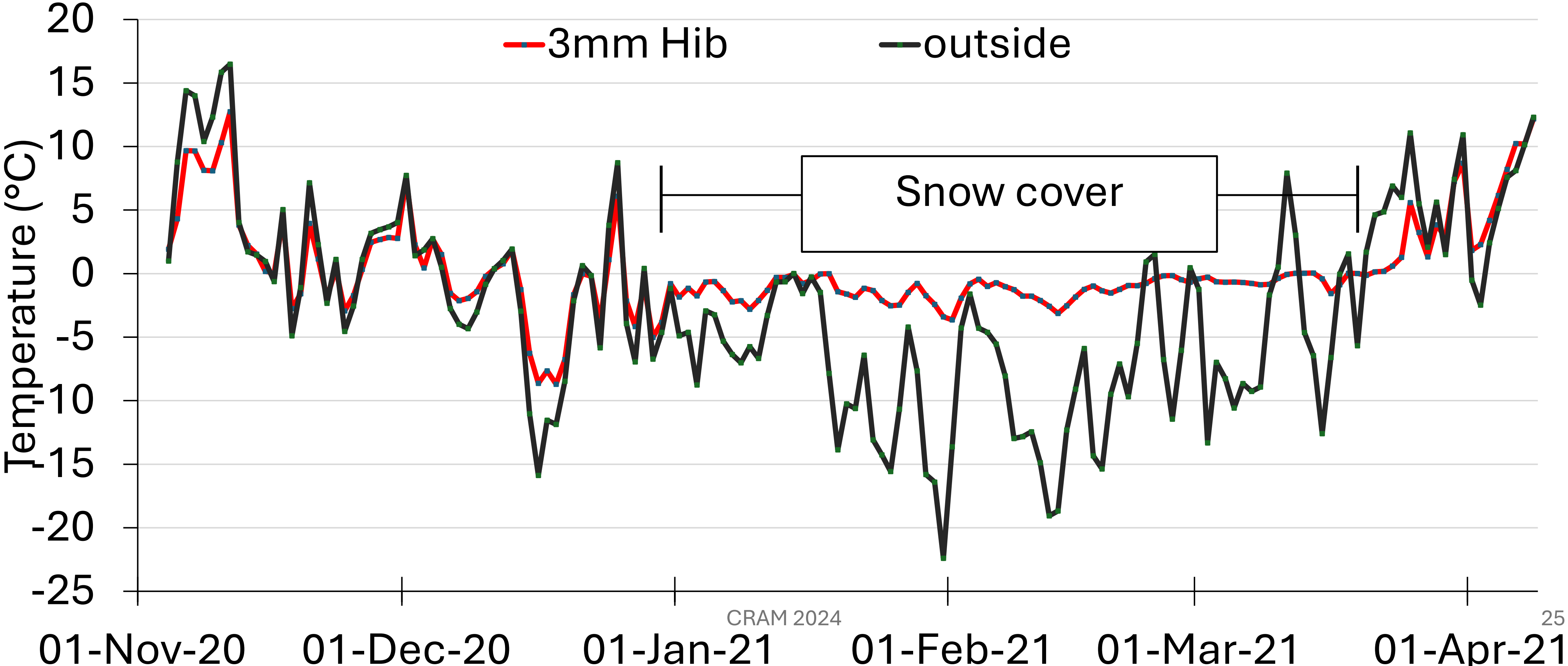
- Questions:
  - **Does the type of geotextile makes a difference?**
  - **Does the timing of geotextile installation and removal influence vine physiology?**

Type of geotextiles and moment of installation and removal

- 3 types of géotextiles (Arbopro, Hibertex 2mm et Hibertex 3mm)
- 2 timing of installation and 2 timing of removal
  - 4 combinations (early/early, early/late, late/early, late/late)
- 5 sites, 3 cultivars, 3 winters (between 2018 and 2022)
- Combinations trials of types x timing as well

Results

The snow and the geotextile act synergistically to maintain non-lethal temperatures around the vines

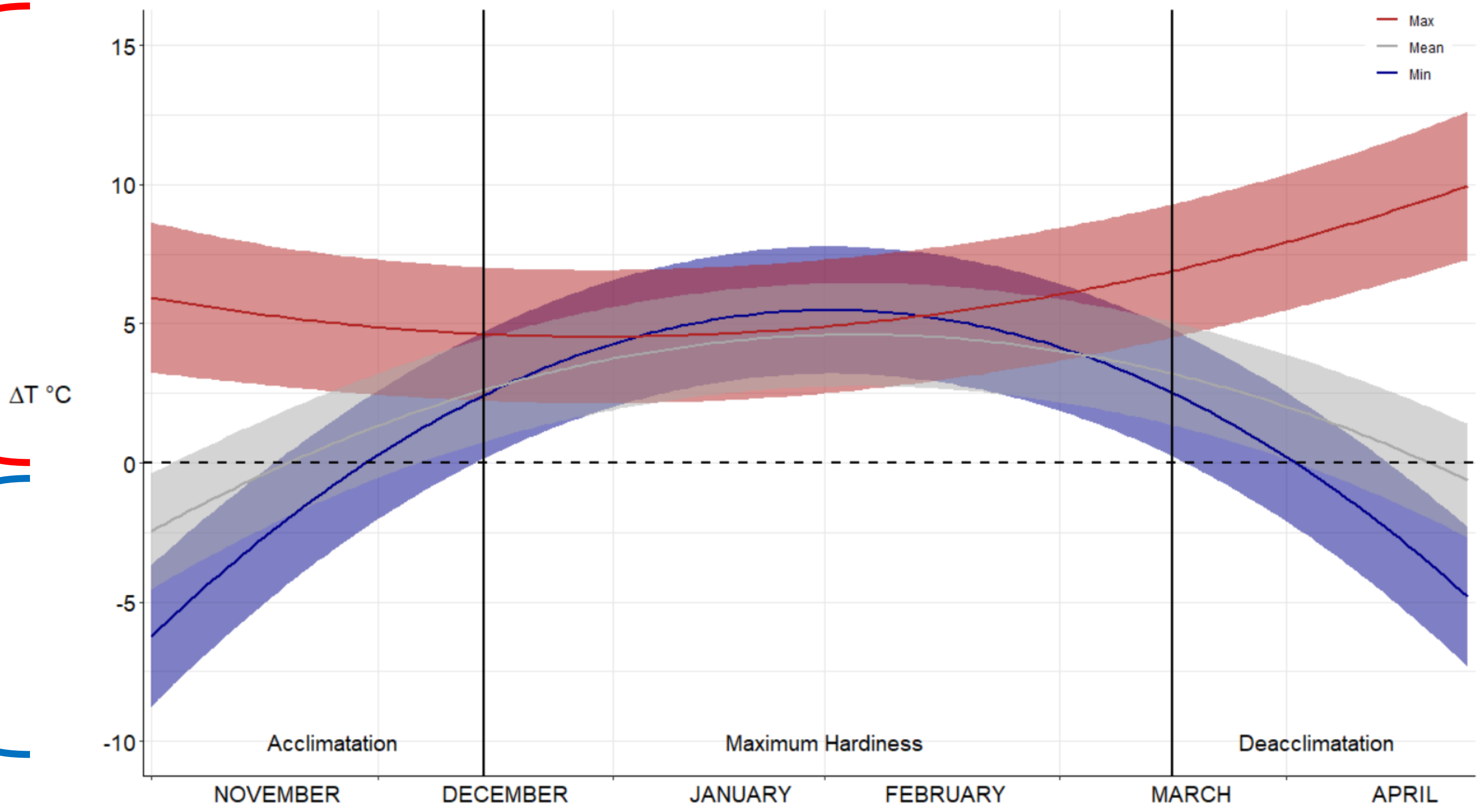


Results

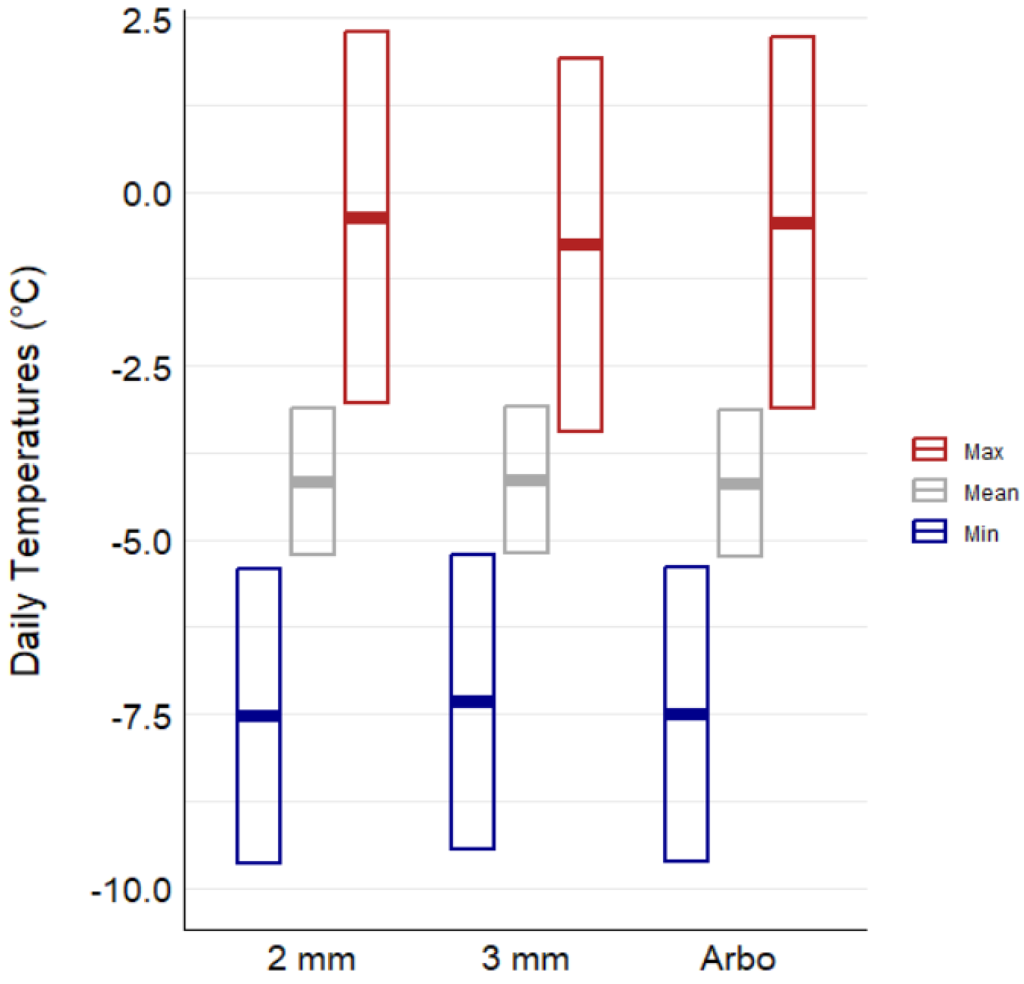
$$\Delta T = Temp\ under\ geotex\ - Temp\ outside$$

Warmer under geotextile

Colder under geotextile

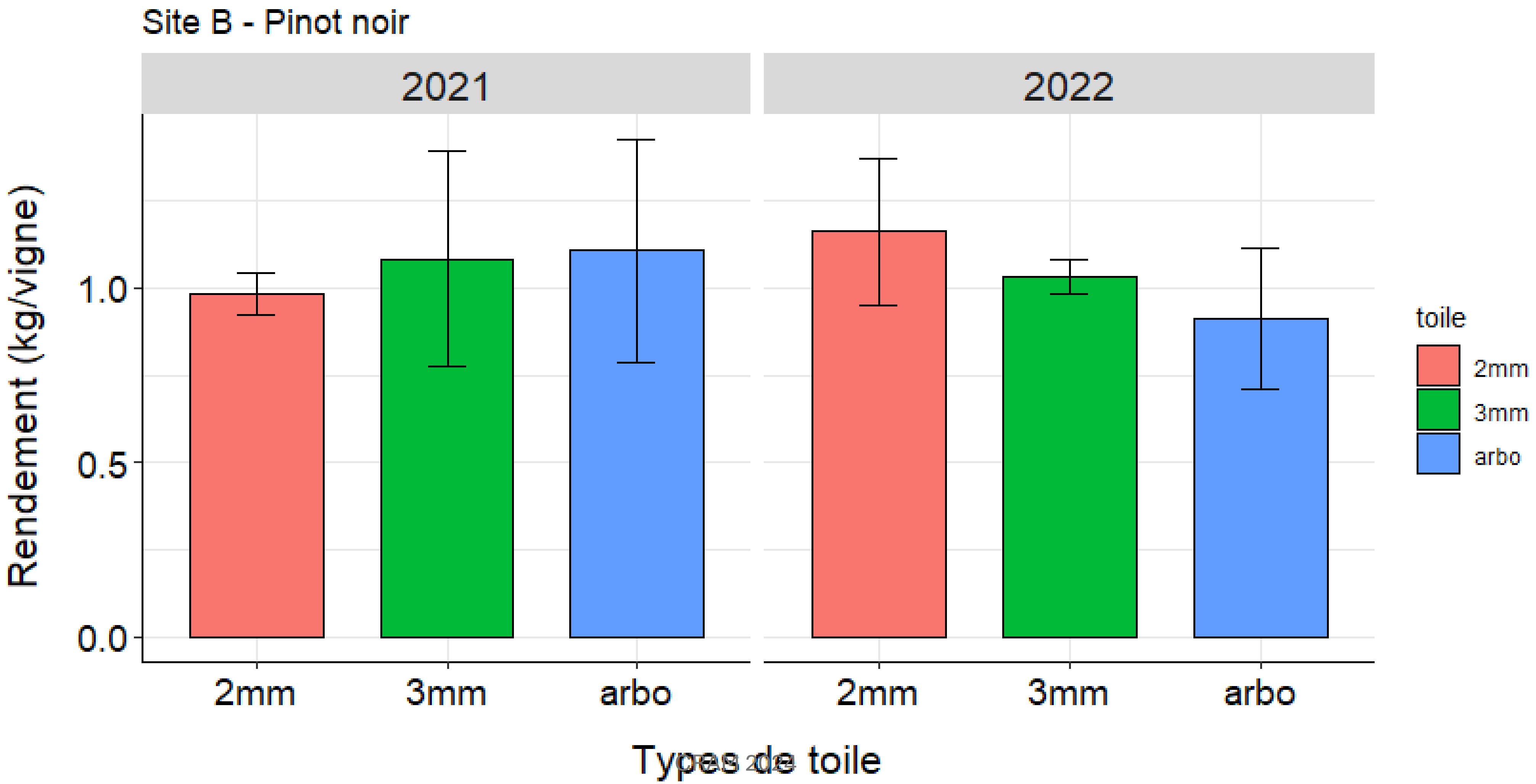


Results

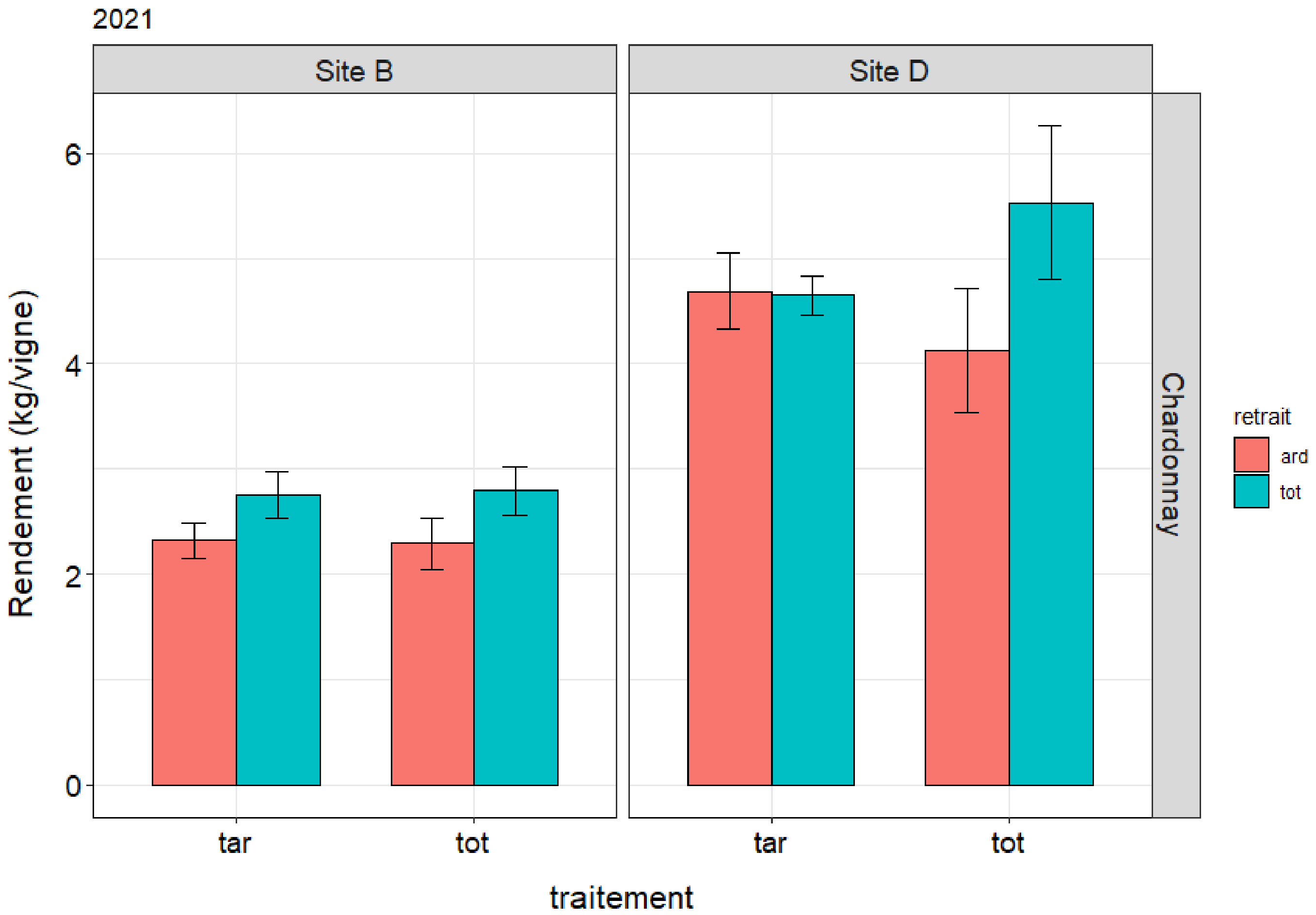


Daily Temperatures (°C)
2.5
0.0
-2.5
-5.0
-7.5
-10.0
2 mm
3 mm
Arbo
Max
Mean
Min

No predictable impact of types



Installation did not matter, but removing early is important



5b: conclusions

- Types of geotextiles
  - No differences in temperature under the geotextile
  - Because no differences between the types of geotextile, no impact on yield or fruit quality
- Timing of installation and removal
  - Small differences during acclimation, but larger one at deacclimation
  - Could make a difference on hardiness and timing of budbreak
  - Small impact on yield and yield components
- Install the geotextile you have, whenever you can… but remove it early

Activity 5

Part 5a
Monitoring system for evaluation of cold hardiness of several grapevine cultivars under climatic condition of Eastern Canada.

Part 5b
Use of winter protection systems to reduce winter injuries of cold sensitive cultivars.

Part 5c
Use of rootstocks to improve cold hardiness of hybrid cultivars.

Activity 5

Evaluate the use of rootstock to improve cold hardiness of hybrid grapevines

Evaluate the impact of rootstock on yields, berry chemistry and wines

Part 5c
Use of rootstocks to improve cold hardiness of hybrid cultivars.

5c: background

- Phylloxera resistance on *vinifera*
  - What about hybrids?
- Adaptation to soil
  - Acidity
  - Composition
  - Drainage
- Impact on vigour
- Impact on berry chemistry and aroma
- Impact on cold hardiness?

5c: rootstock trial

Cépages	Porte-greffes
Adalmiina	Pied franc
Baltica	101-14
Frontenac	3309C
Frontenac blanc	Riparia gloire
Frontenac gris	SO4
Marquette	

- Planted in Oka in 2013
  - 8 vine of each combo in each block with RCBD
  - Double cordon, 8 buds per cordon
  - Well-drained sandy loam
  - 1.20 m (vine) x 2.44 m (row)

Combinaisons	Cépages	Porte-greffes
1	Frontenac	3309
2	Frontenac Gris	3309
3	Frontenac Blanc	3309
4	Aldamiina	3309
5	Baltica	3309
6	Marquette	3309
7	Frontenac	SO4
8	Frontenac Gris	SO4
9	Frontenac Blanc	SO4
10	Aldamiina	SO4
11	Baltica	SO4
12	Marquette	SO4
13	Frontenac	Riparia Gloire
14	Frontenac Gris	Riparia Gloire
15	Frontenac Blanc	Riparia Gloire
16	Aldamiina	Riparia Gloire
17	Baltica	Riparia Gloire
18	Marquette	Riparia Gloire
19	Frontenac	101-14
20	Frontenac Gris	101-14
21	Frontenac Blanc	104-14
22	Aldamiina	101-14
23	Baltica	101-14
24	Marquette	101-14
25	Frontenac	Frontenac
26	Frontenac Gris	Frontenac Gris
27	Frontenac Blanc	Frontenac Blanc
28	Aldamiina	Aldamiina
29	Baltica	Baltica
30	Marquette	Marquette

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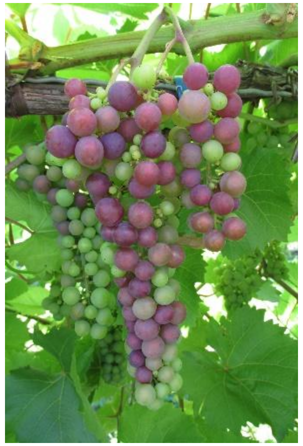
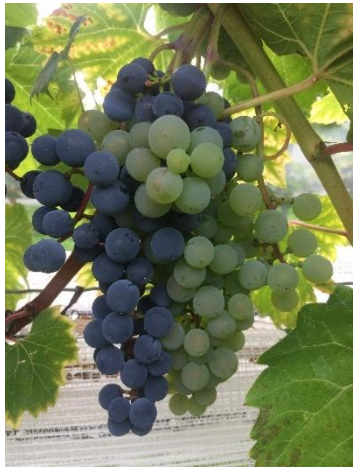
5c: methods

- Vine development monitoring
  - Phenology
  - Vigour and growth
  - Periderm formation
  - Disease susceptibility and mineral deficiency
  - Bud survival
- Harvest parameters
  - Yield
  - Berry chemistry
- Winemaking





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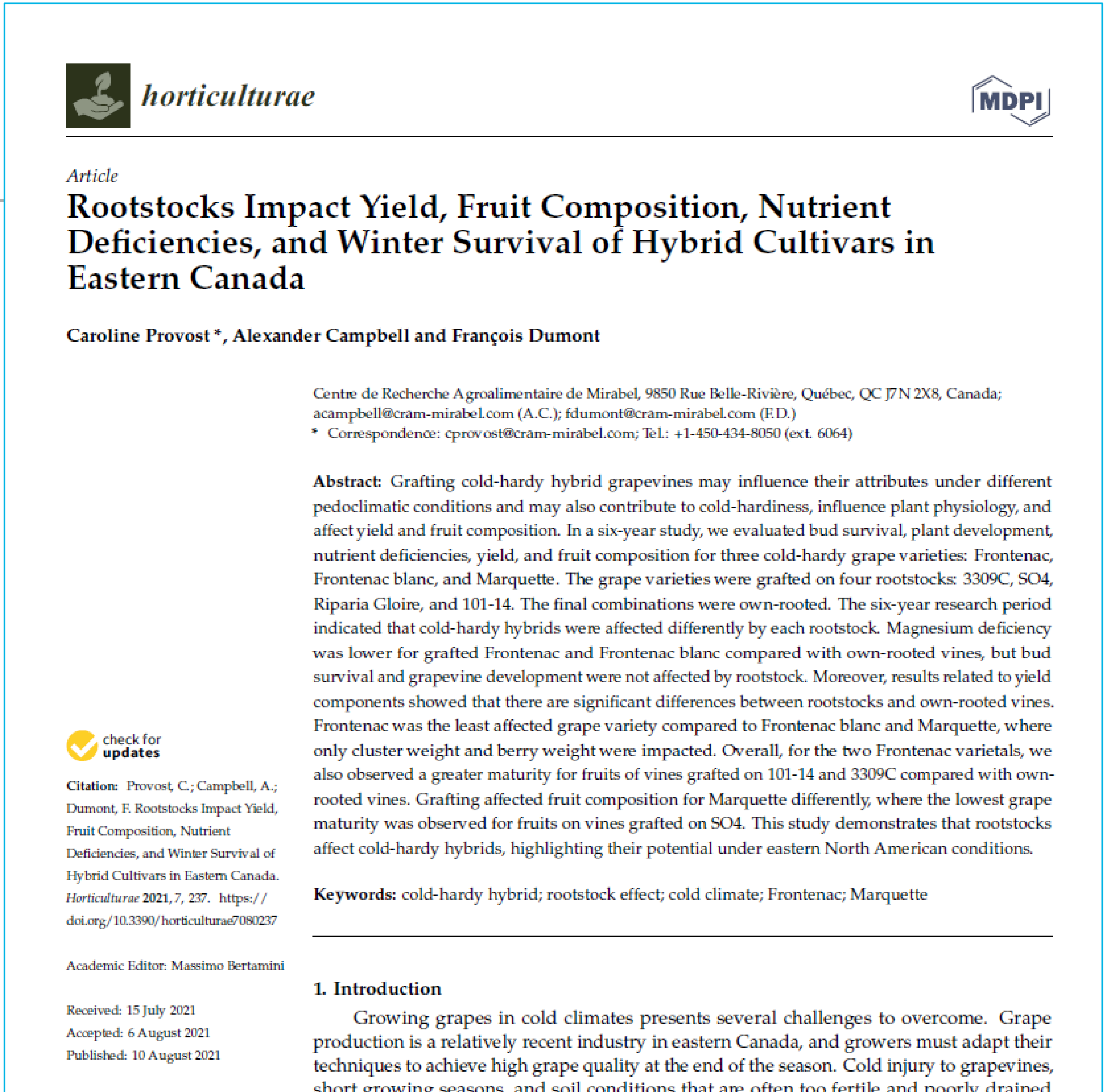
Results

- Check out Provost et al. 2021



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MDPI

Article

Rootstocks Impact Yield, Fruit Composition, Nutrient Deficiencies, and Winter Survival of Hybrid Cultivars in Eastern Canada

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Abstract: Grafting cold-hardy hybrid grapevines may influence their attributes under different pedoclimatic conditions and may also contribute to cold-hardiness, influence plant physiology, and affect yield and fruit composition. In a six-year study, we evaluated bud survival, plant development, nutrient deficiencies, yield, and fruit composition for three cold-hardy grape varieties: Frontenac, Frontenac blanc, and Marquette. The grape varieties were grafted on four rootstocks: 3309C, SO4, Riparia Gloire, and 101-14. The final combinations were own-rooted. The six-year research period indicated that cold-hardy hybrids were affected differently by each rootstock. Magnesium deficiency was lower for grafted Frontenac and Frontenac blanc compared with own-rooted vines, but bud survival and grapevine development were not affected by rootstock. Moreover, results related to yield components showed that there are significant differences between rootstocks and own-rooted vines. Frontenac was the least affected grape variety compared to Frontenac blanc and Marquette, where only cluster weight and berry weight were impacted. Overall, for the two Frontenac varietals, we also observed a greater maturity for fruits of vines grafted on 101-14 and 3309C compared with own-rooted vines. Grafting affected fruit composition for Marquette differently, where the lowest grape maturity was observed for fruits on vines grafted on SO4. This study demonstrates that rootstocks affect cold-hardy hybrids, highlighting their potential under eastern North American conditions.

Keywords: cold-hardy hybrid; rootstock effect; cold climate; Frontenac; Marquette

Citation: Provost, C.; Campbell, A.; Dumont, F. Rootstocks Impact Yield, Fruit Composition, Nutrient Deficiencies, and Winter Survival of Hybrid Cultivars in Eastern Canada. *Horticulturae* 2021, 7, 237. https://doi.org/10.3390/horticulturae7080237

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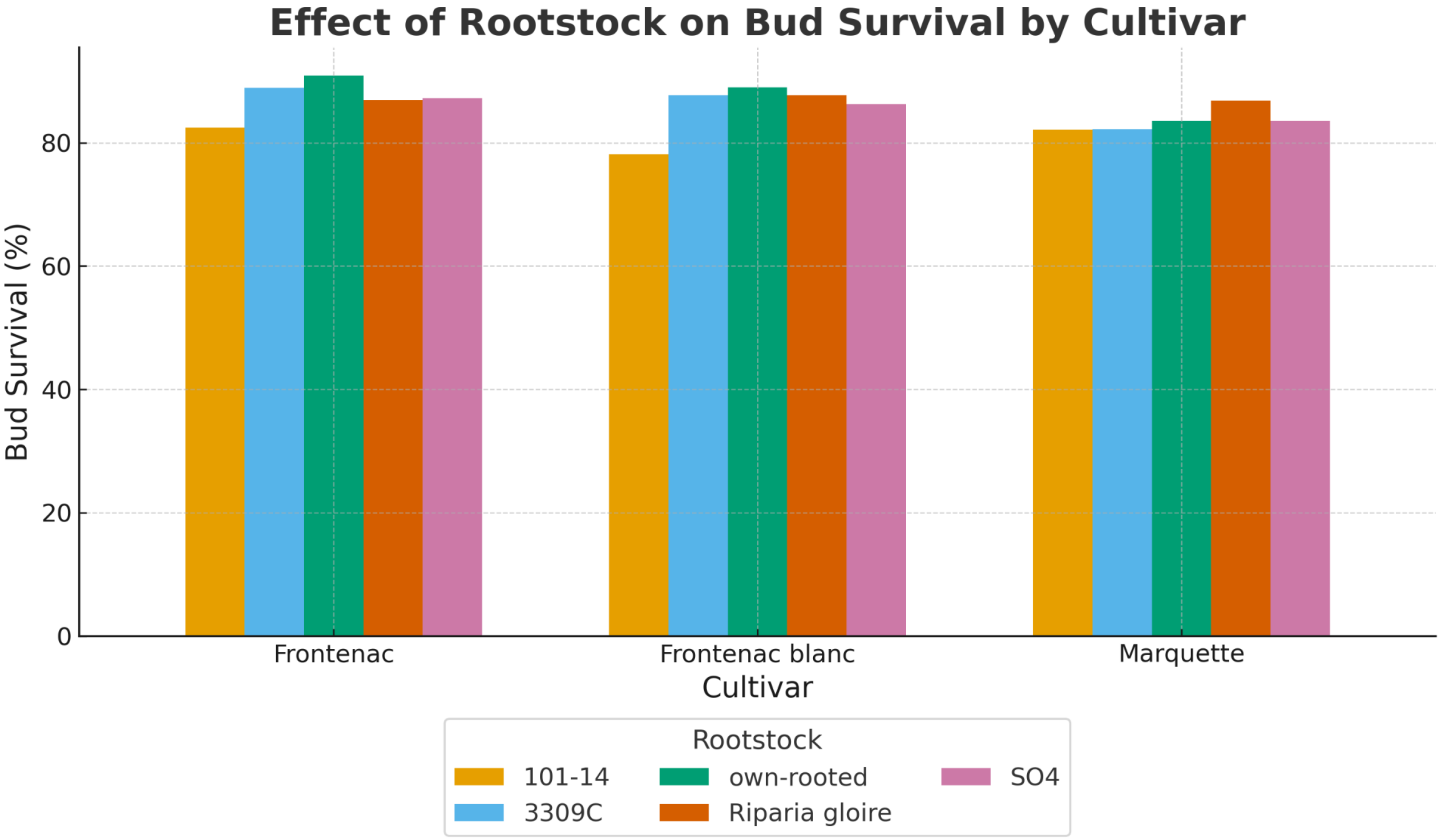
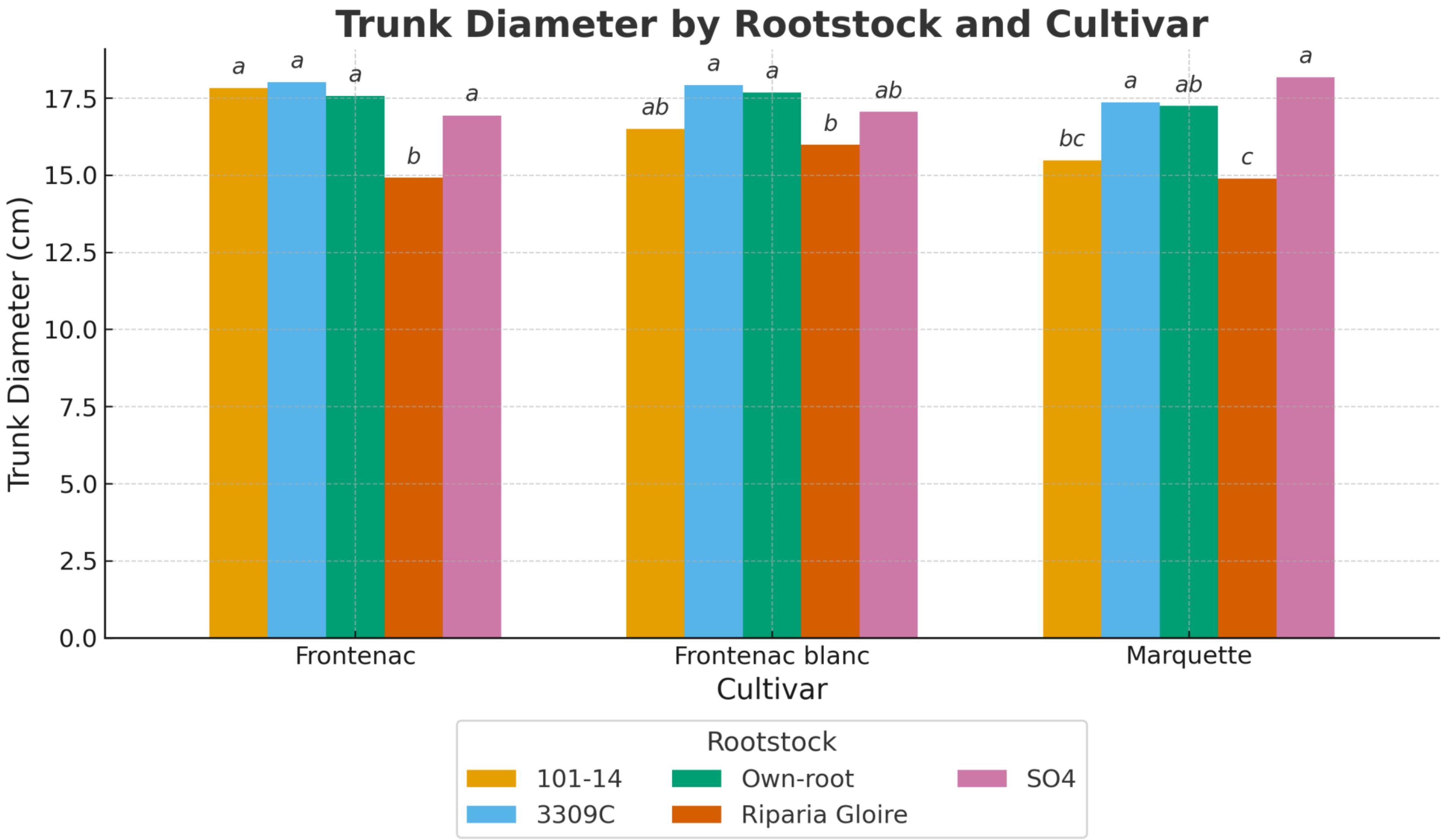
1. Introduction

Growing grapes in cold climates presents several challenges to overcome. Grape production is a relatively recent industry in eastern Canada, and growers must adapt their techniques to achieve high grape quality at the end of the season. Cold injury to grapevines, short growing seasons, and soil conditions that are often too fertile and poorly drained

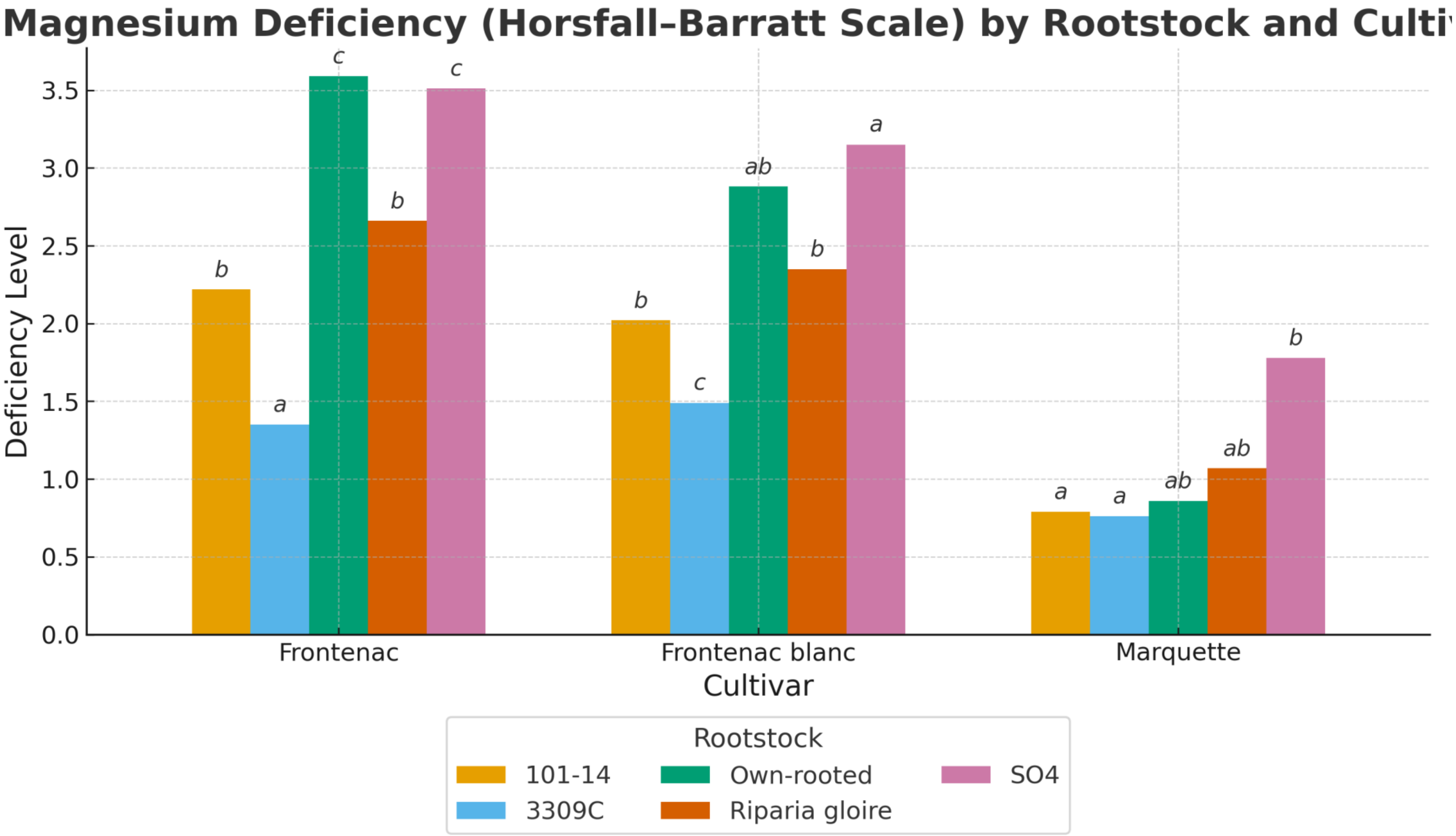
Selected results



Selected results



Selected results



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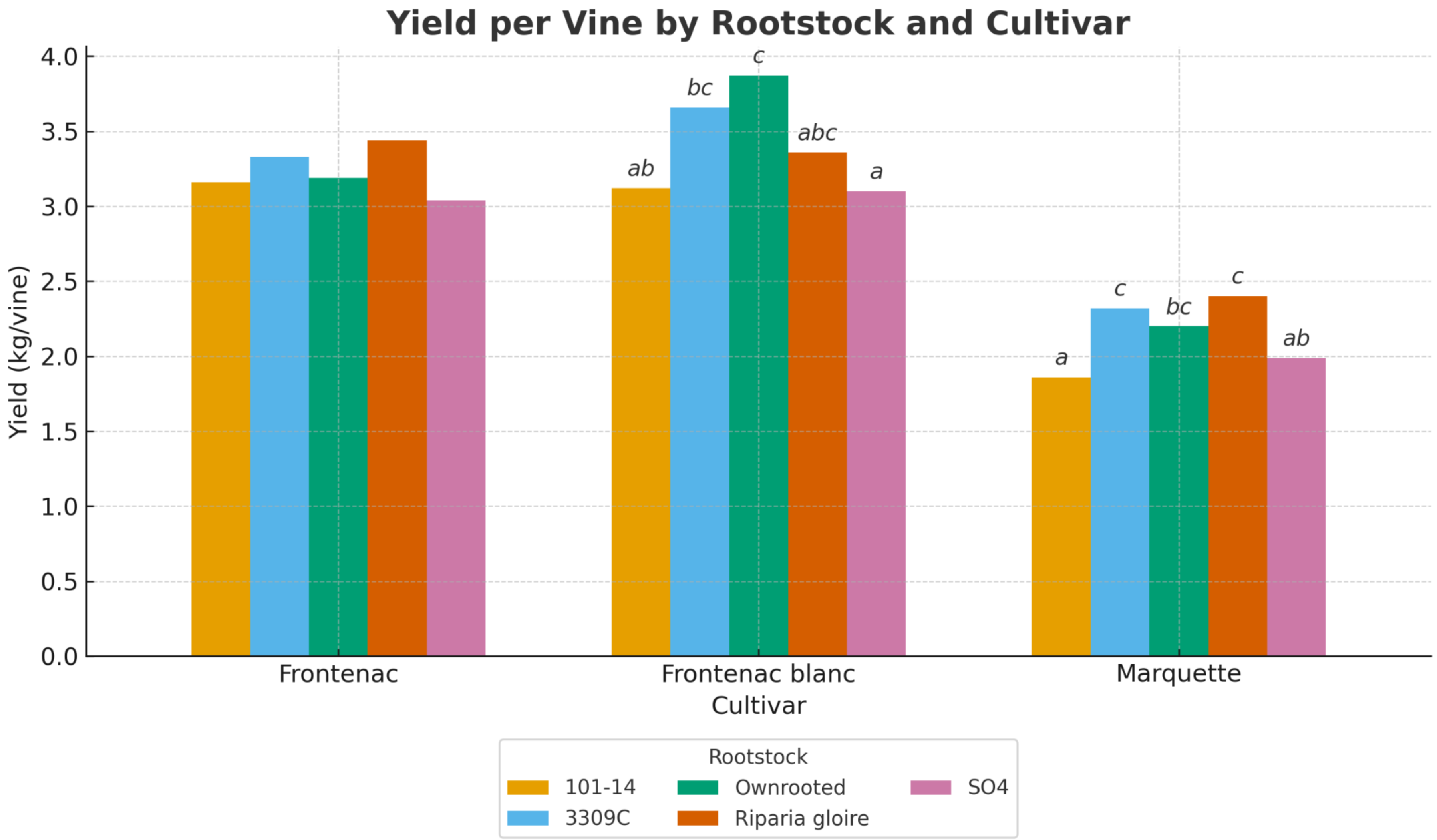
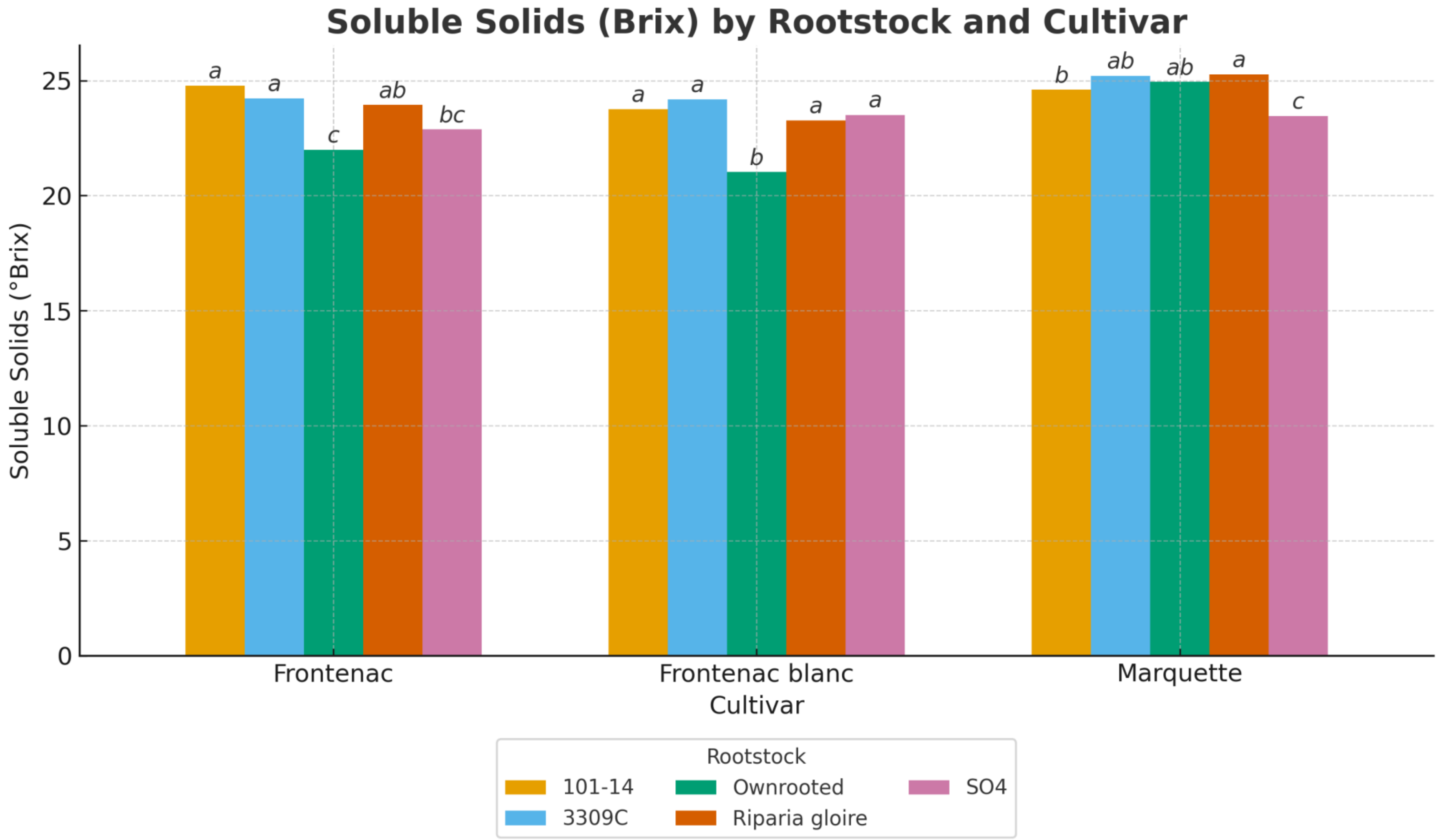


Selected results



5c: outcomes

- Rootstocks influence cold-hardy hybrid grapevines, with effects varying by cultivar
- Bud survival and vine development were not significantly affected by rootstock choice
- Other parameters were impacted to some degrees
  - Magnesium deficiency was greatly impacted by rootstock
  - Yield components were variable
  - Impact on fruit maturity was cultivar dependant
- Rootstocks may provide a useful tool for adapting cold-hardy hybrids to eastern North American growing conditions.

Activity 5 (2018-2023) → Activity 14 (2023-2028)

Part 5a
Monitoring system for evaluation

↓

Activity 14a
1. Understanding the interrelation of cold hardiness and dormancy
2. Identifying hardiness-related metabolites

Part 5b
Use of geotextile

↓

Activity 14b
Understanding the impact of geotextile on dormancy and hardiness with consideration for soil temperature and light

Part 5c
Use of rootstocks

Activity 14c
Cold protection with new technologies
1. Cellulose nanocrystal
2. Abscicic acid
3. Heated wires

CRAM

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Canada

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Conseil des vins du Québec

Canadian Grapevine Certification Network
CGCN · RCCV
Réseau canadien de certification de la vigne

Cool Climate Oenology & Viticulture Institute
Brock University

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