A decade of freezing buds and blankets. The trials and tribulations of cold hardiness and freeze protection research

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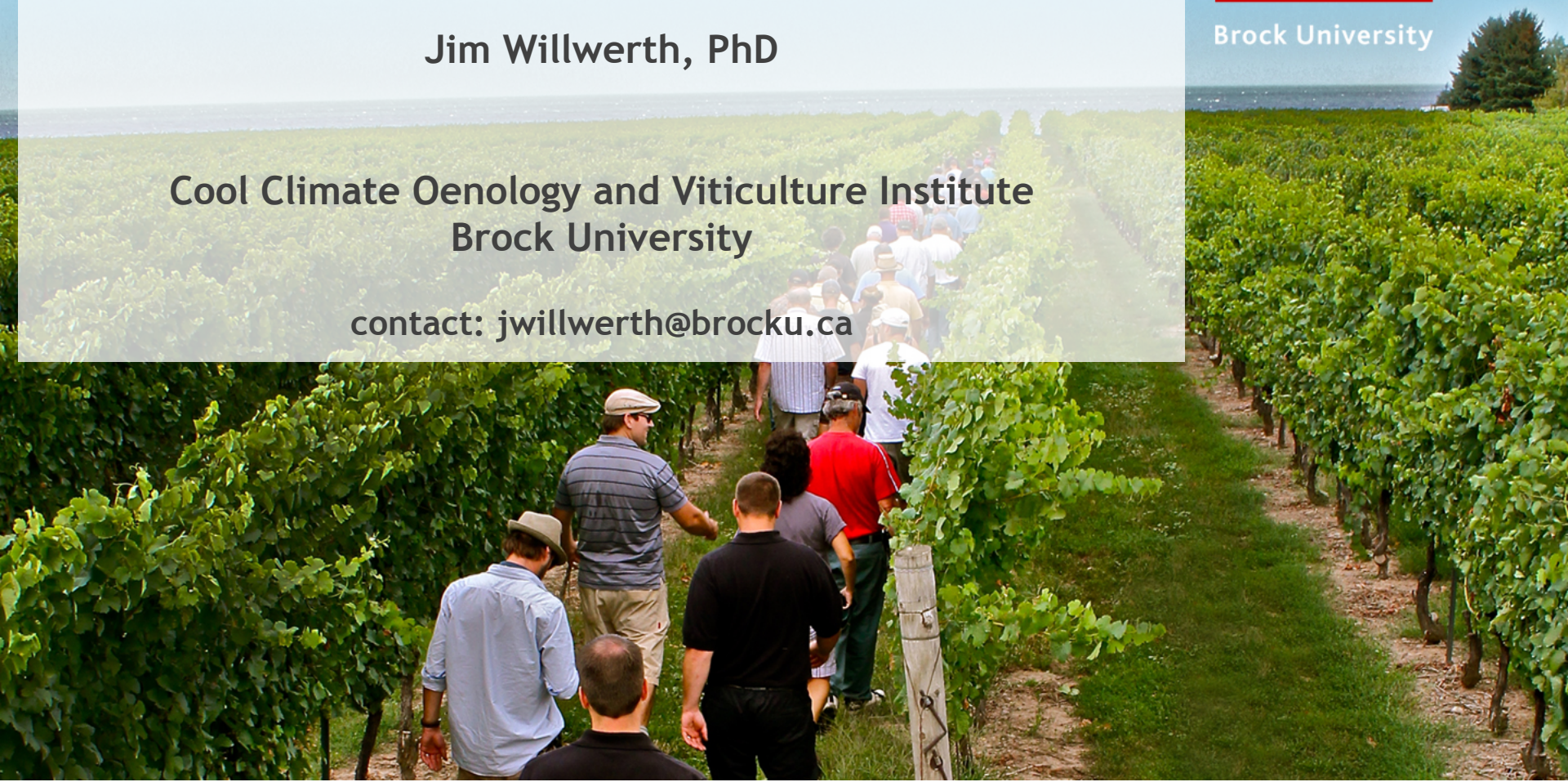

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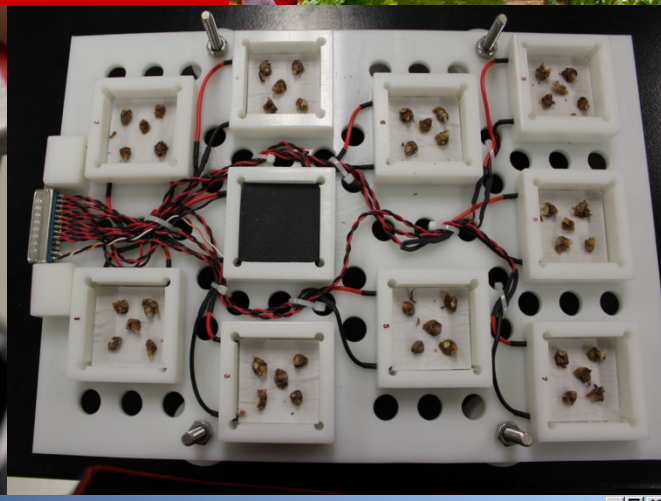
Cold hardiness research and outreach at CCOVI

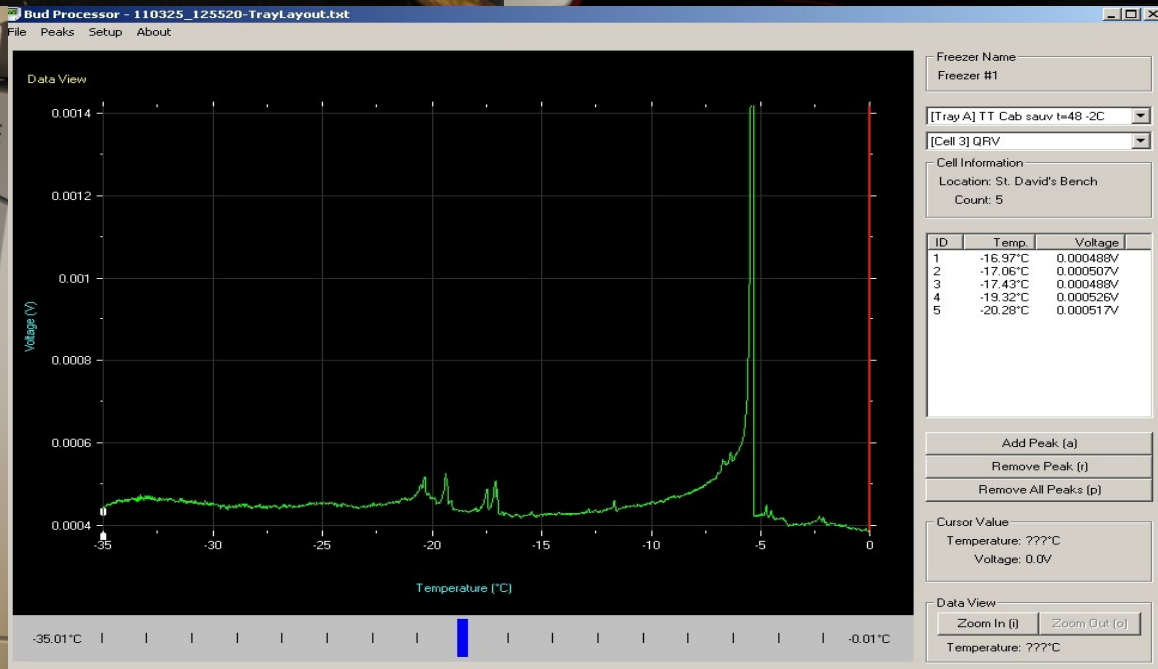
- Research and outreach initiatives began in 2010
- Priorities were to develop programs to address winter injury
- Research: optimize hardiness in *V. vinifera*
- Outreach: Develop a program to monitor cold hardiness of grapevines throughout Ontario to mitigate freeze injury

Outreach program: VineAlert

- The largest outreach initiative was the establishment of VineAlert
- Partnerships with various stakeholders including OGWRI, GGO, AAFC and others
- Collaborations with Kevin Ker, Ryan Brewster, Weather Innovations
- Sampling done with many growers/wineries across the province

Knowing is half the battle. Testing cold hardiness using Differential Thermal Analysis (DTA)





VineAlert
http://www.ccovi.ca/vine-alert

- **Our advanced cold hardiness database and alerting system during periods of risk**
- **Stores, displays, disseminates all information related to grapevine cold hardiness and injury**

Custom display of cold hardiness

Logout

Vine Alert: Bud Hardiness

Estimating the lowest temperatures grape buds can survive in.

Overview | Recent | Bud Hardiness | Bud Survival | Alerts | Resources

Location: Niagara Peninsula | Beamsville Bench — Use Map »

Variety: Riesling

Year: 2013 / 2014

View Most Recent Data across all Varieties and Locations »

Table | Comparison-Table | Chart | Comparison-Chart

Bud Hardiness Data for **Riesling** at **Beamsville Bench in 2013/2014**

Edit	Sampling Date	LTE 10	LTE 50	LTE 90
Edit	March 26, 2014	-19.8°C	-21.1°C	-22.3°C
Edit	March 11, 2014	-21.2°C	-23.2°C	-25.1°C
Edit	February 26, 2014	-21.8°C	-23.8°C	-25.5°C
Edit	February 12, 2014	-23.8°C	-25.2°C	-25.9°C
Edit	January 29, 2014	-21.7°C	-23.8°C	-26.5°C
Edit	January 15, 2014	-22.1°C	-24.0°C	-25.0°C

Show/Hide More Data »

Change to °F

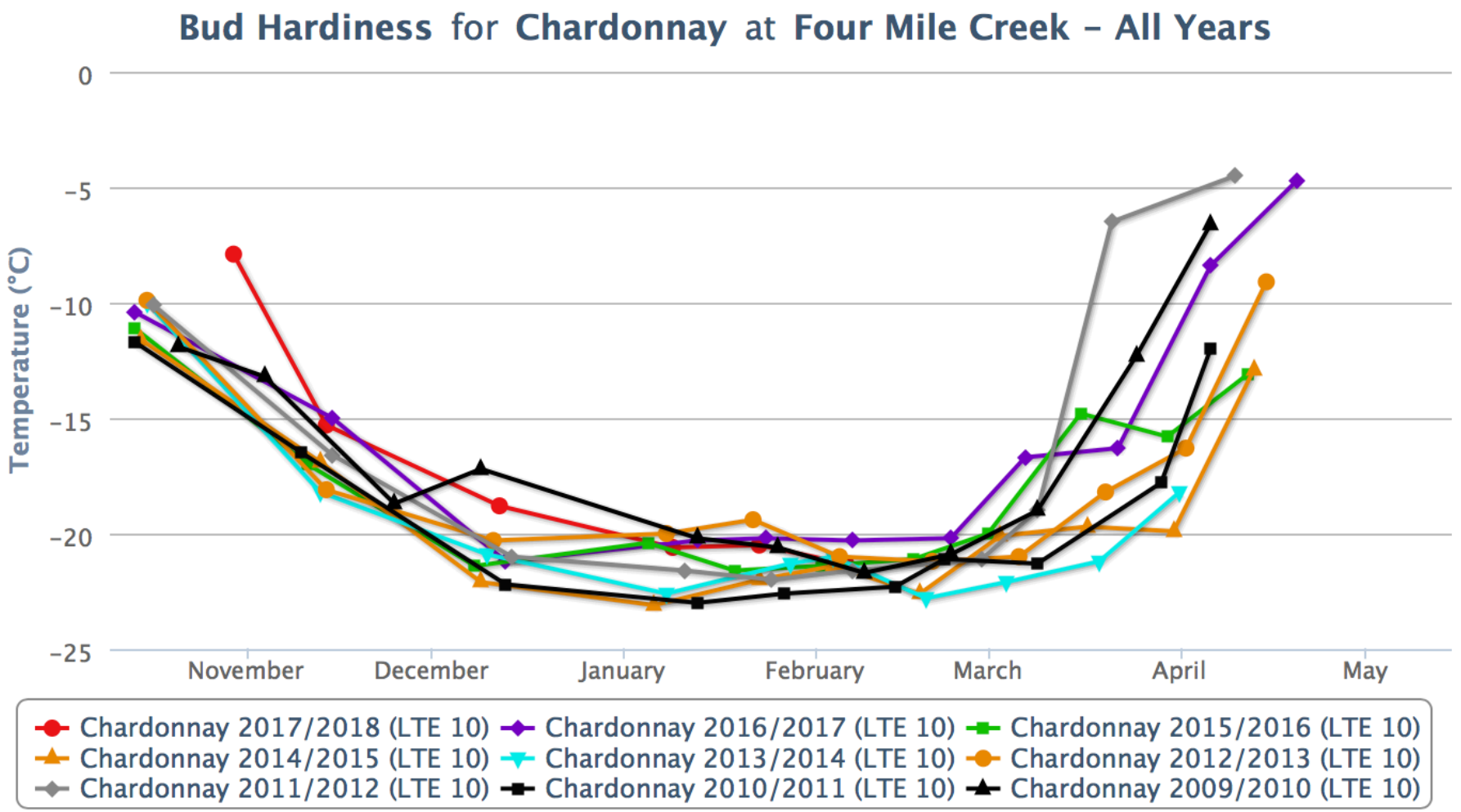
An example of how to read this data:

As of March 26th, according to estimates:

- If temperature drops below -19.8°C, 10% of primary buds will die.
- If temperature drops below -21.1°C, 50% of primary buds will die.
- If temperature drops below -22.3°C, 90% of primary buds will die.

NOTE: Your individual situation will vary by numerous factors.
Please read the Resources page for more information.

VineAlert: seasonal differences in cold hardiness



Cultivar differences

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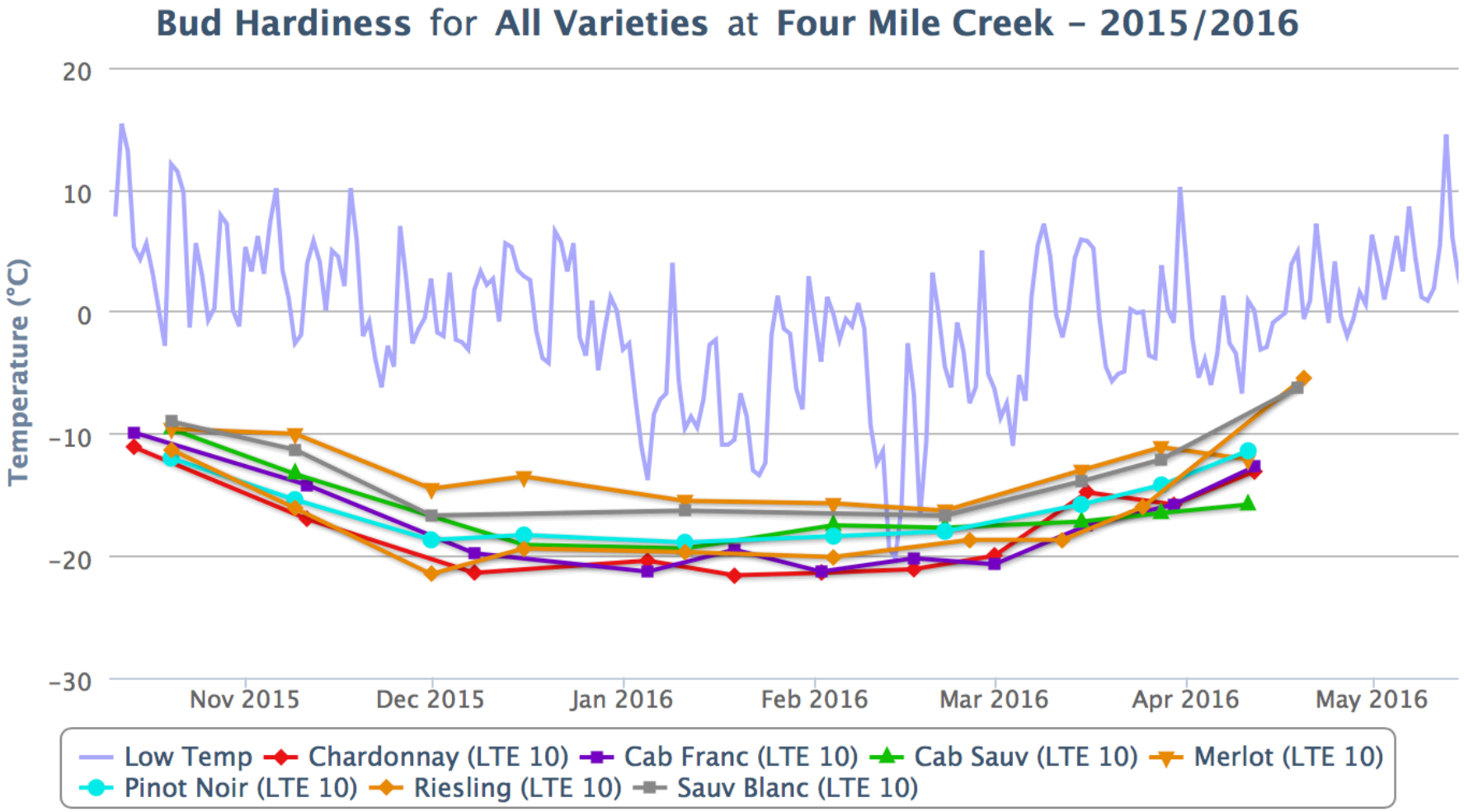
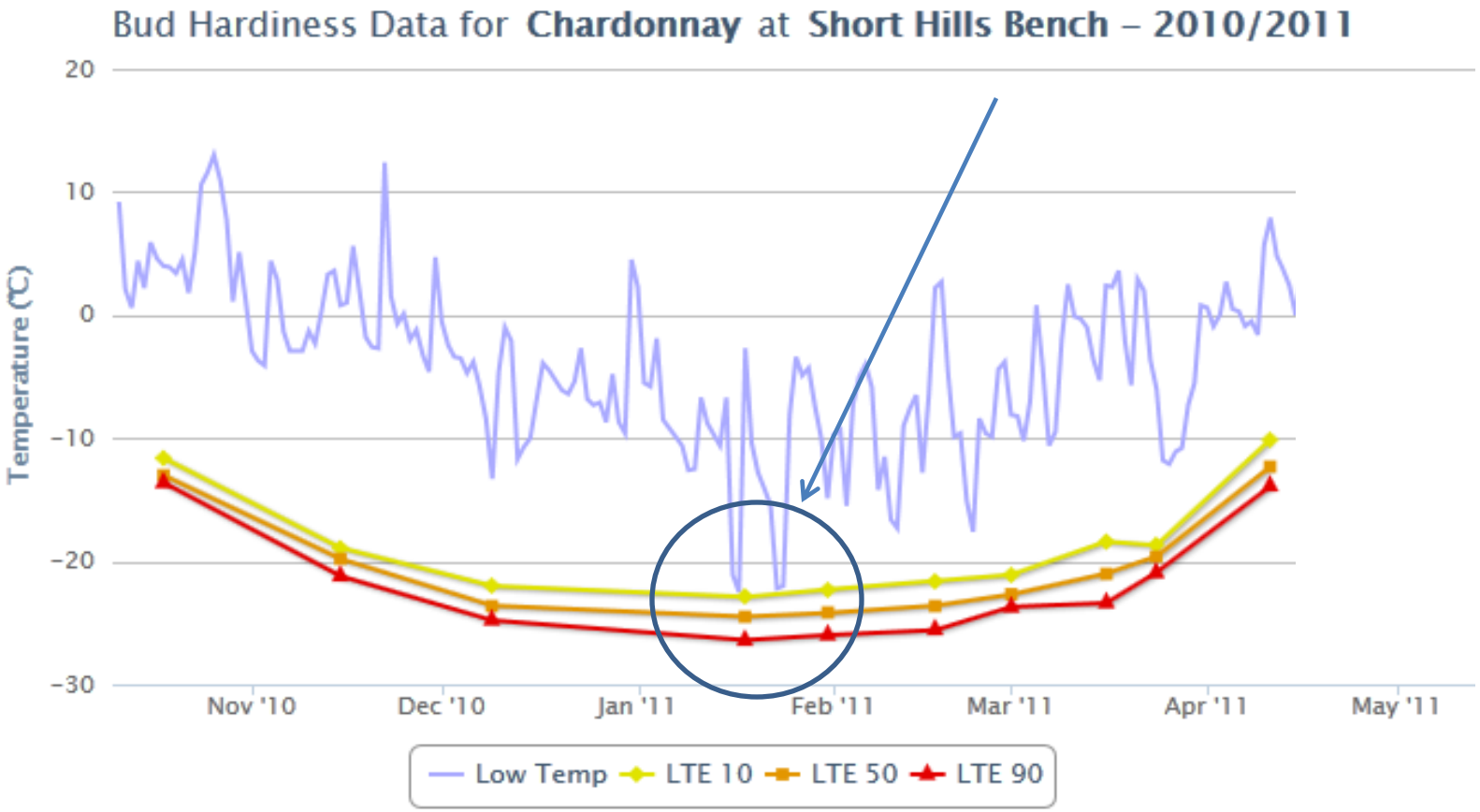


Cultivar differences of cold hardiness dynamics, Four Mile Creek sub-appellation, NOTL. 2015-2016. (CCOVI VineAlert website)

VineAlert indicating possible winter injury from cold weather events

Table | Comparison-Table | Chart | Comparison-Chart



VineAlert: Bud survival
Tracking survival rates after cold events

Logout

Vine Alert: Bud Survival

Tracking the survival rates of grape buds.

Overview | Recent | Bud Hardiness | Bud Survival | Alerts | Resources

Location: Niagara Peninsula | Short Hills Bench

Variety: Chardonnay

Year: 2010 / 2011

Use Map »

NOTE: We also have PDF versions of the Bud Survival Data available.

Bud Survival Data for **Chardonnay** at **Short Hills Bench - 2010/2011**

Edit	Sampling Date	Survival Rate (%)
Edit	March 7, 2011	68.0
Edit	January 24, 2011	66.0
Edit	January 21, 2011	67.0
Edit	December 17, 2010	85.0

Alert functionality:
Notification of new data or messages sent to prepare growers to take action

CCOVI Vine Alert

vinealert@ccovi.ca

Sent: Fri 21/03/2014 2:35 PM

To: Jim Willwerth

Hi Jim,

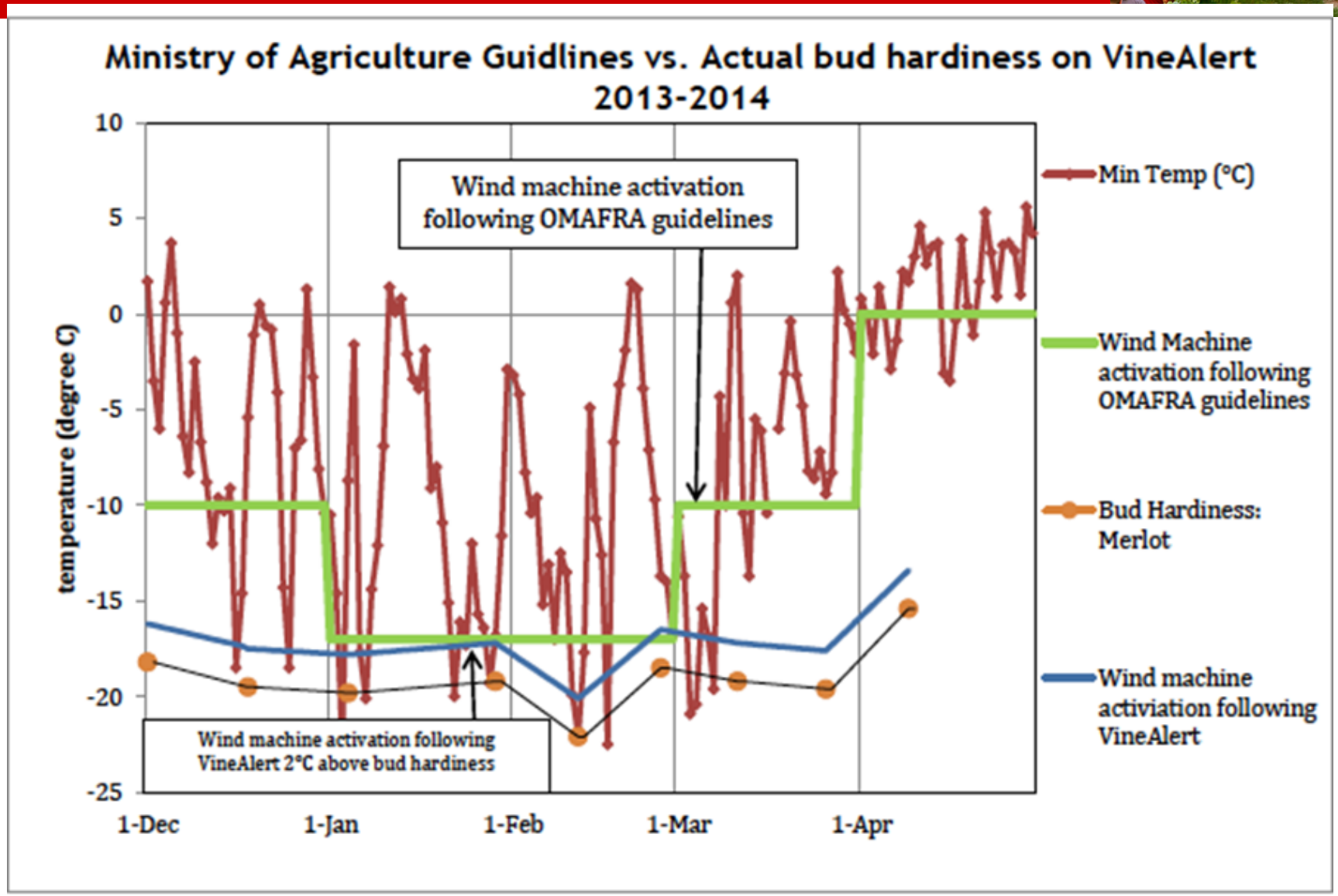
New Bud Hardiness data is available on the Vine Alert website for Chardonnay in Four Mile Creek, sampled on March 19
can view it by visiting the following link:
http://www.ccovi.ca/vine-alert/bud-hardiness#/a_3/sa_5/v_1

You can manage these alerts by visiting the following link:
http://www.ccovi.ca/vine-alert/alerts

For your reference, your login username is:
vitccovi

Thank you for using Vine Alert

Protecting vines only when needed

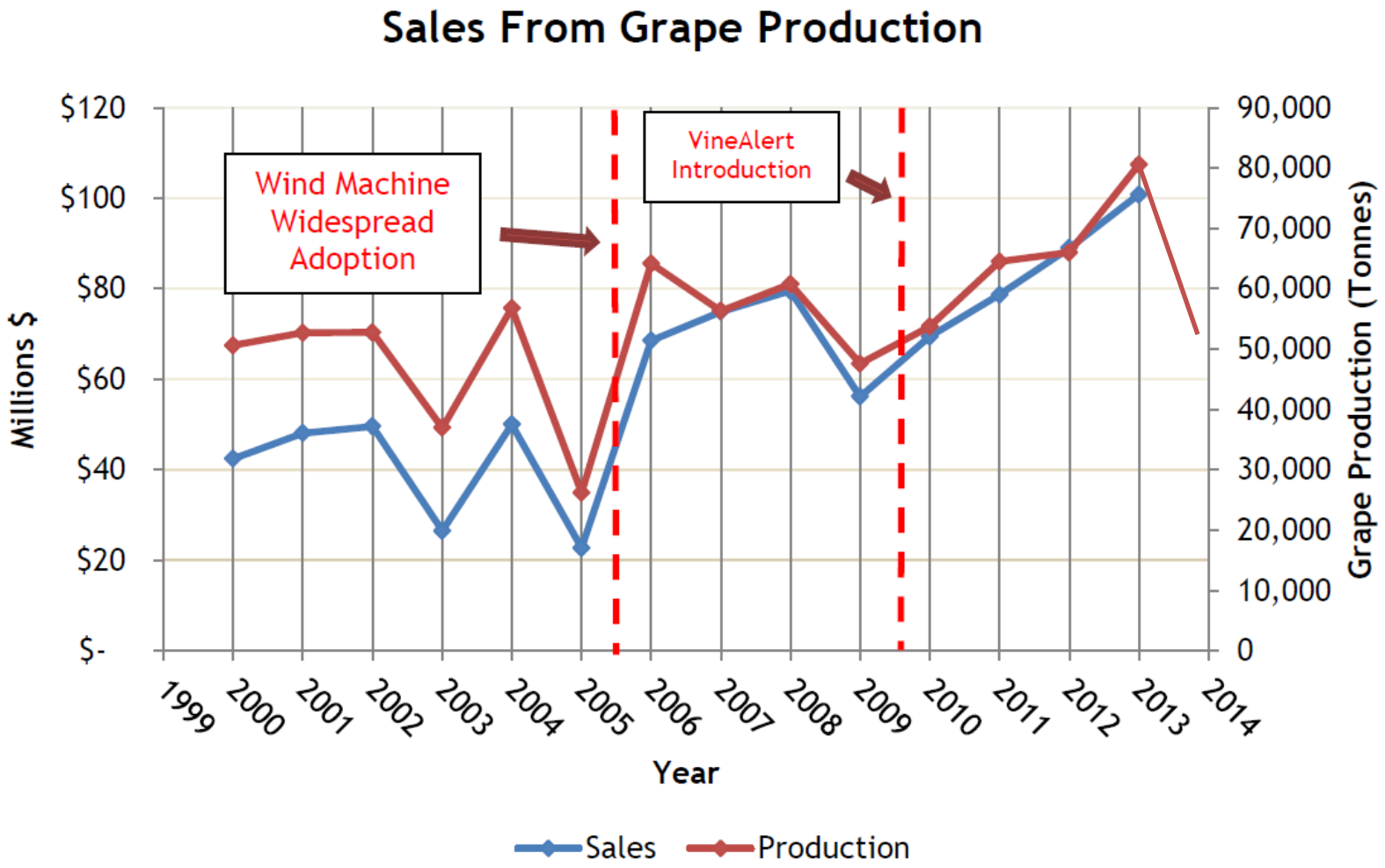


How has VineAlert helped Ontario?

- **Directly protecting fruiting buds and vintages**
  - Saved crops every year since its launch and at many different stages of dormancy
  - $13.8 M worth of production saved in the initial year following a cold event
- **Reduced wind machine usage**
  - Over $1 M/year saved in fuel costs alone across the industry.
- **Saved growers from renewing or replacing vines**
  - $29.1 Million over 5 years in savings!
- **Improved farmer/neighbour relations**
- **Helped educate community and government about freeze risks and protection**

Tonnage and Sales (1999-2014)

(Economic analysis of VineAlert, Goodman School of Business, 2014)



Winter protection in cool climate regions with low minimum winter temperatures

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Winter protection strategies

- Wind machines are used in the major grape production areas of Ontario for freeze mitigation
- Other regions cannot depend on wind machines for mid-winter protection because minimum temperatures are too low
- Vines may be buried with soil for protection but yields and vine health can be compromised
- Therefore, an alternative strategy was examined

Use of Geotextiles for winter protection

- Geotextiles are permeable fabrics that can be used for winter protection of crops
- First used in vineyards in Quebec, Canada
- Interest in Ontario vineyards have increased

Temperature mitigation

		Temperature (°C) 2015-16		Temperature (°C) 2016-17	
Month	Temperature	Ambient	Geotextile	Ambient	Geotextile
November	Maximum	14.41	14.39	12.05	15.68
	Minimum	-10.41	-5.73	-5.76	-4.17
	Average	3.29	3.75	3.49	3.64
December	Maximum	14.48	13.74	8.97	15.08
	Minimum	-8.33	-6.07	-22.27	-15.79
	Average	3.71	3.85	-1.25	-0.59
January	Maximum	7.12	5.75	7.95	13.91
	Minimum	-22.52	-12.83	-21.42	-14.24
	Average	-4.85	-1.13	-1.95	-0.70
February	Maximum	8.69	10.83	14.46	18.91
	Minimum	-33.61	-15.06	-16.74	-7.67
	Average	-4.97	-2.03	-1.21	0.60
March	Maximum	14.46	22.13	13.33	20.13
	Minimum	-14.47	-9.68	-17.04	-11.08
	Average	0.46	3.17	-1.73	1.37

Spring


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Outcomes of research

- Yields were consistently higher using geotextiles
- Growers across Ontario are now starting to experiment and use them in commercial operations
- Yield increases are reported to be around 30% or more compared to burying of vines
- Other regions across Canada, US as well as other international regions have expressed interest and/or experimenting with them

Mitigating Freeze injury: Warmer winters and climate change

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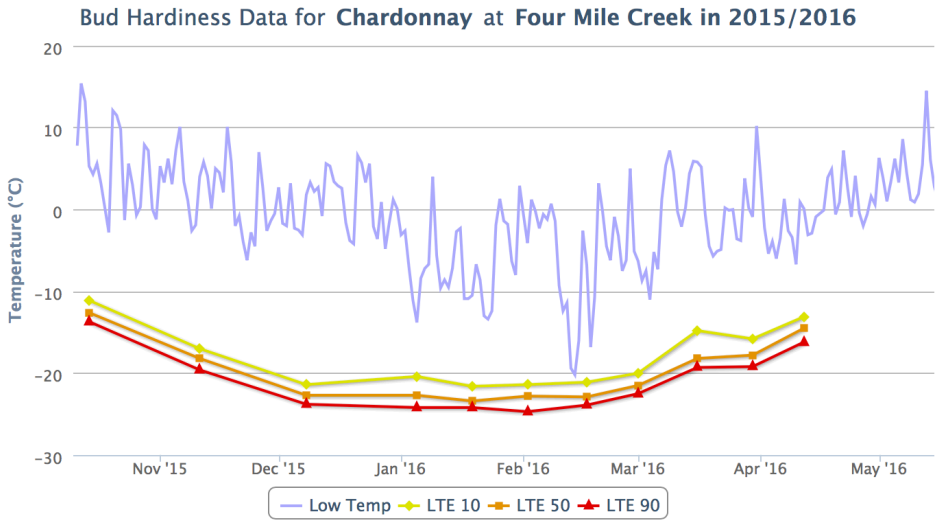
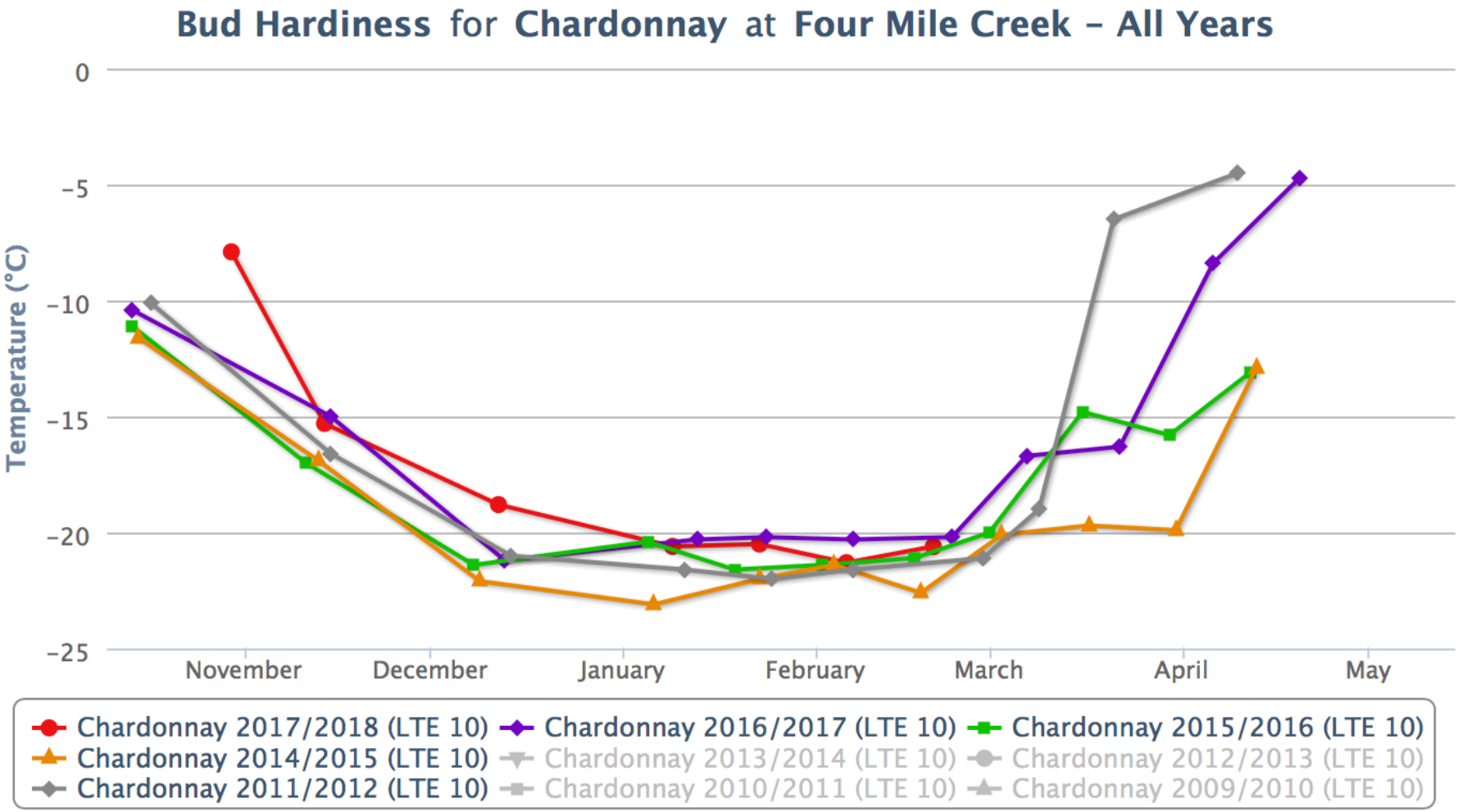
Warming during ecodormancy

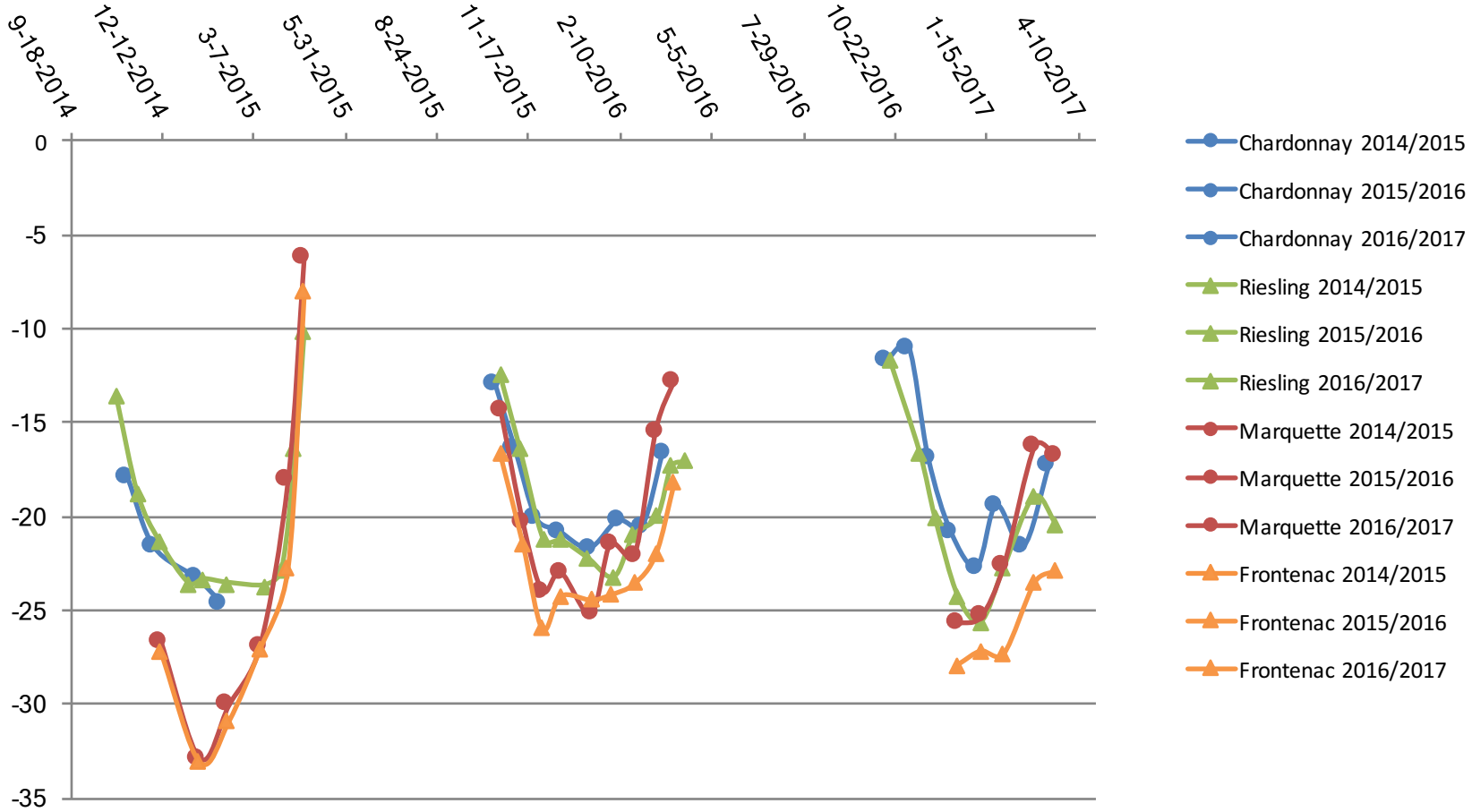
- Probably the greatest risk of freeze injury due to climate change
- More erratic winter temperatures
- Periods of warming followed by ‘extreme’ cold can have devastating consequences



Impacts of warm weather on deacclimation



The difference a winter makes with cold hardiness of hybrids

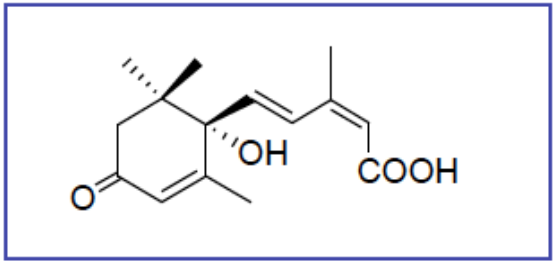


Trials to improve or maintain cold hardiness

- **Multiple collaborative trials were performed to improve onset of dormancy**
- **Later to examine how to maintain dormancy and delay budbreak**
- **Use of Plant Growth Regulators**
  - Abscisic acid and abscisic acid analogs

Background on Abscisic Acid (ABA)

- **Isoprenoid plant hormone found in all plants**
- **Regulates a wide range of processes in plant growth and development**
  - Response to abiotic stress
    - Transpiration
    - Response to heat, drought, salinity and freezing
  - Growth and development
    - Growth inhibition
    - Abscission, senescence
    - Secondary metabolite production
  - Seed Development



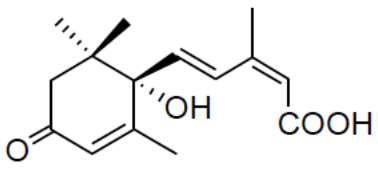
S-(+)-Abscisic acid

ABA and cold tolerance

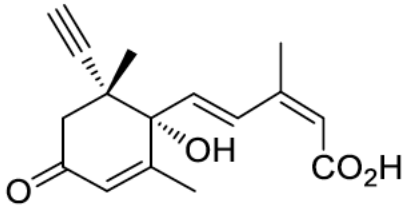
- **Enforces dormancy in buds**
  - Induction and maintenance of dormancy
- **Induces expression of genes encoding proteins to protect cells from dehydration**
- **Interacts with other signaling molecules (i.e. Ca) to regulate cold tolerance responses**
- **Impacts expression of CBF genes**
- **Induce dehydrin gene expression and accumulation of COR proteins**
- **ABA dependent and independent pathways**
- **Complex interactions with abiotic conditions**

Abscisic Acid (ABA) analogs

- **ABA analogs more effective than natural ABA for improving cold acclimation**
  - 8'-Acetylene ABA
  - Purported to catabolize more slowly in plant tissues
  - Maintain high bioactivity
  - providing enhanced or prolonged effects on dormancy and hardiness



Natural ABA



8'-Acetylene ABA

Collaborative study examining the use of natural ABA and ABA analogs

Abscisic acid form, concentration, and application timing influence phenology and bud cold hardiness in Merlot grapevines

Pat Bowen, Krista C. Shellie, Lynn Mills, Jim Willwerth, Carl Bogdanoff, and Markus Keller

Can. J. Plant Sci. 96: 347–359 (2016)

Overview of experiment

- Foliar applications of ABA and ABA analogs in 4 distinct regions
- Different forms, concentrations and timing used in Merlot grapevines
- Measured hardiness, monitored bud break/phenology, yield and fruit components

ABA analogs (ABA_A) can delay deacclimation under warm conditions (ON)

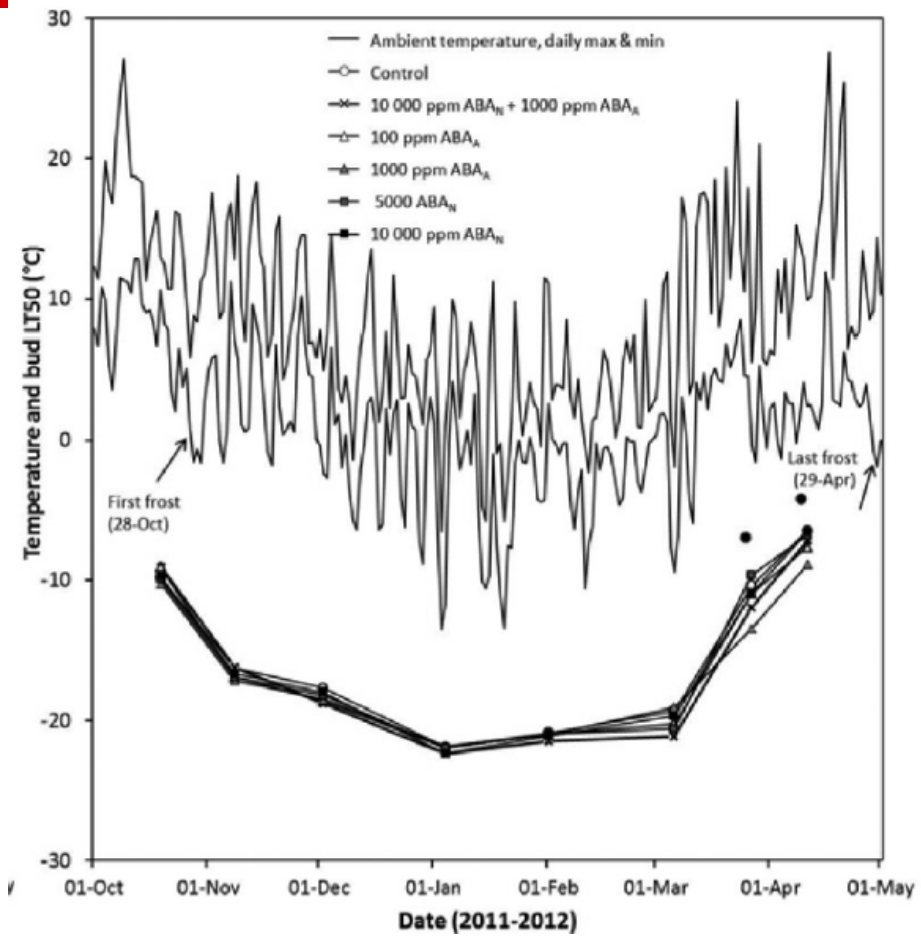


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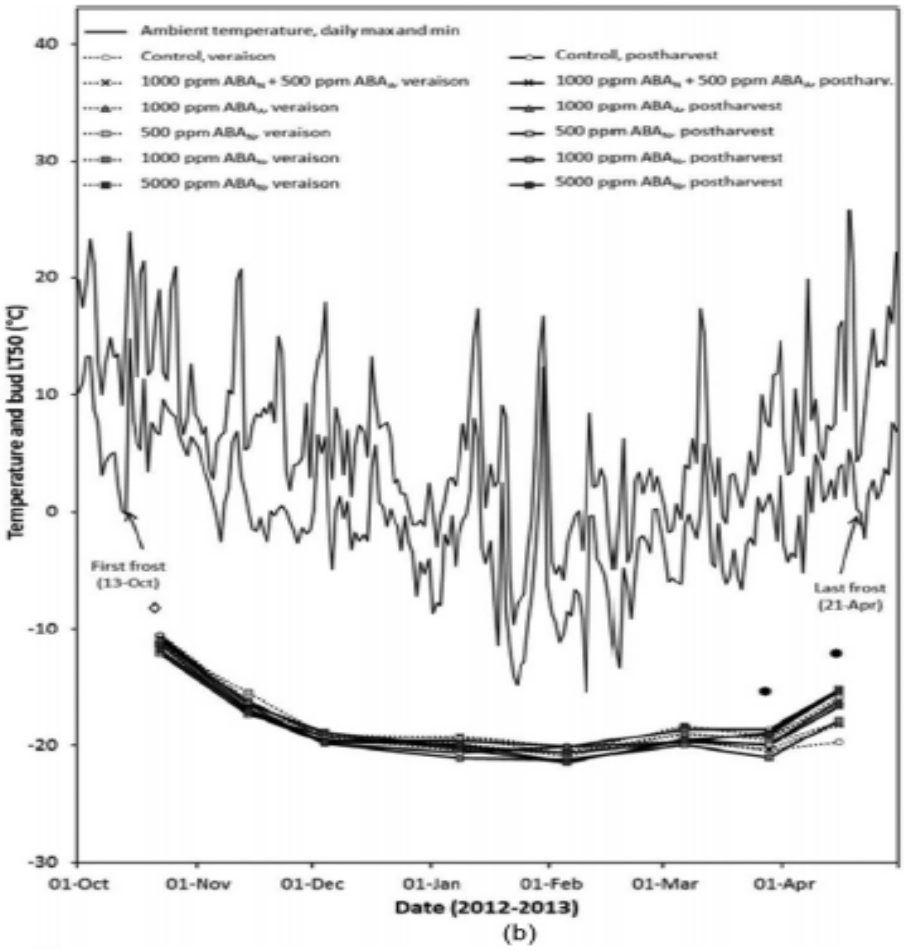
Fig. 3. Bud cold hardiness of Merlot grapevines in (a) British Columbia, (b) Ontario, (c) Idaho, and (d) Washington during winter 2012–2013 after foliar applications of ABA_A and ABA_N were applied at veraison or postharvest in 2012. Hardiness was identified as the lethal temperature for 50% of sampled buds (LT50). Daily minimum and maximum air temperature and dates of first and last frost at the trial location are presented. Significance of effects: ○, ABA_A applied at veraison, linear or vs control at $p \leq 0.05$; ●, ●●, ABA_A applied postharvest, linear or vs control at $p \leq 0.05$ and 0.01, respectively; ◊, ◊◊, ABA_N applied at veraison, linear or vs control at $p \leq 0.05$ and 0.01, respectively; ♦, ♦♦, ABA_N applied postharvest, linear or vs control at $p \leq 0.05$ and 0.01, respectively; ❖, ABA_N and ABA_A combination applied postharvest vs control at $p \leq 0.05$; and ★★, ABA treatments applied at veraison vs postharvest at $p = 0.01$.

ABA analogs (ABA_A) can improve acclimation and delay deacclimation (ON)



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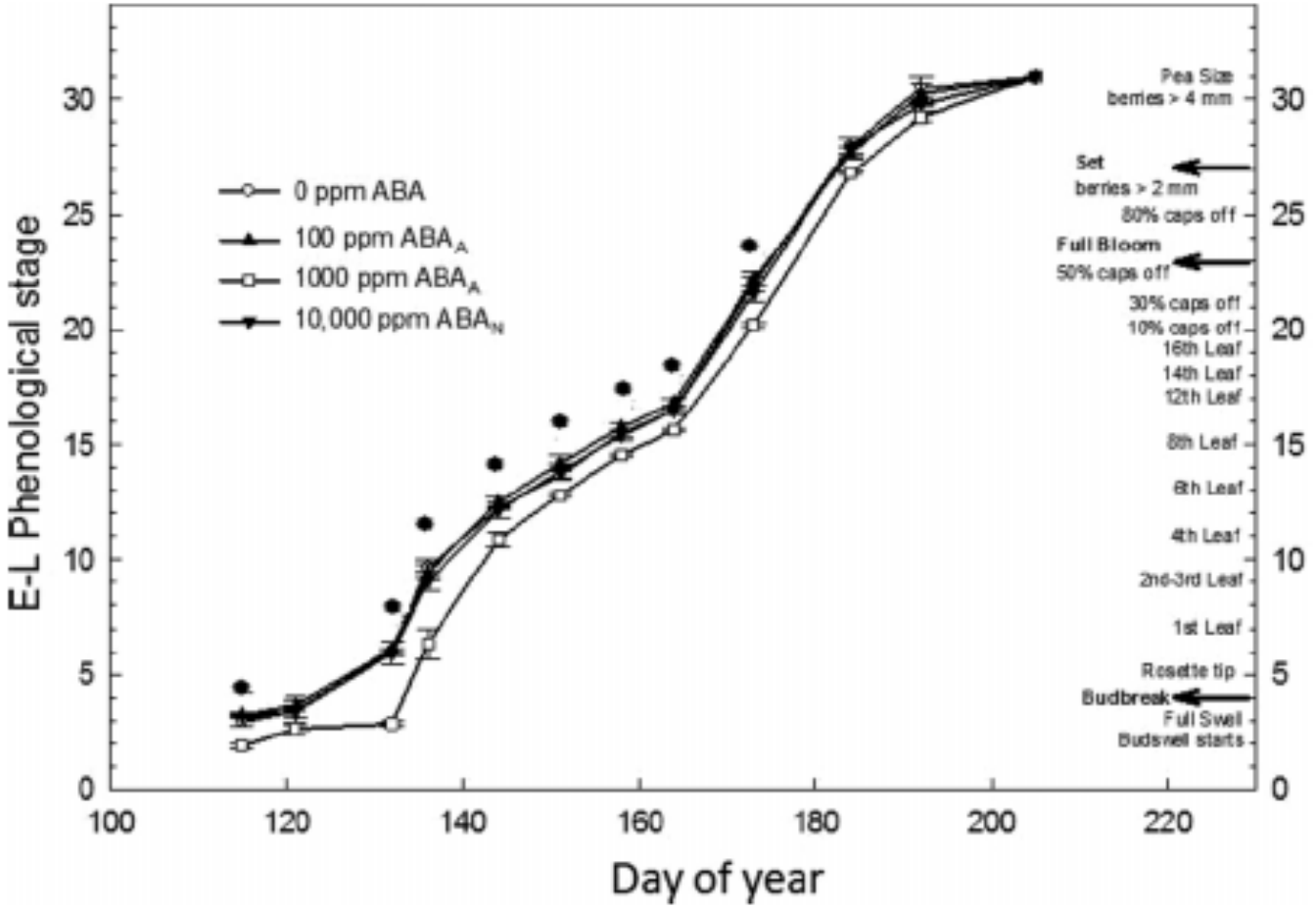
Delay of bud break in warm winters

Treatment	% Bud break April 27 2012
0.1% Brij 98 (control)	92.7a
100 ppm VBC-30158	11.3c
1000 ppm VBC-30158	10.0c
5,000ppm VBC-30101	74.3b
10,000ppm VBC-30101	69.7b
10,000 ppm VBC-30101 & 1000 ppm VBC-30158	15.0c
Significance of F-value	P<0.0001

ABA_A impact on bud break and early development



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New ABA analogs and how they help maintain dormancy

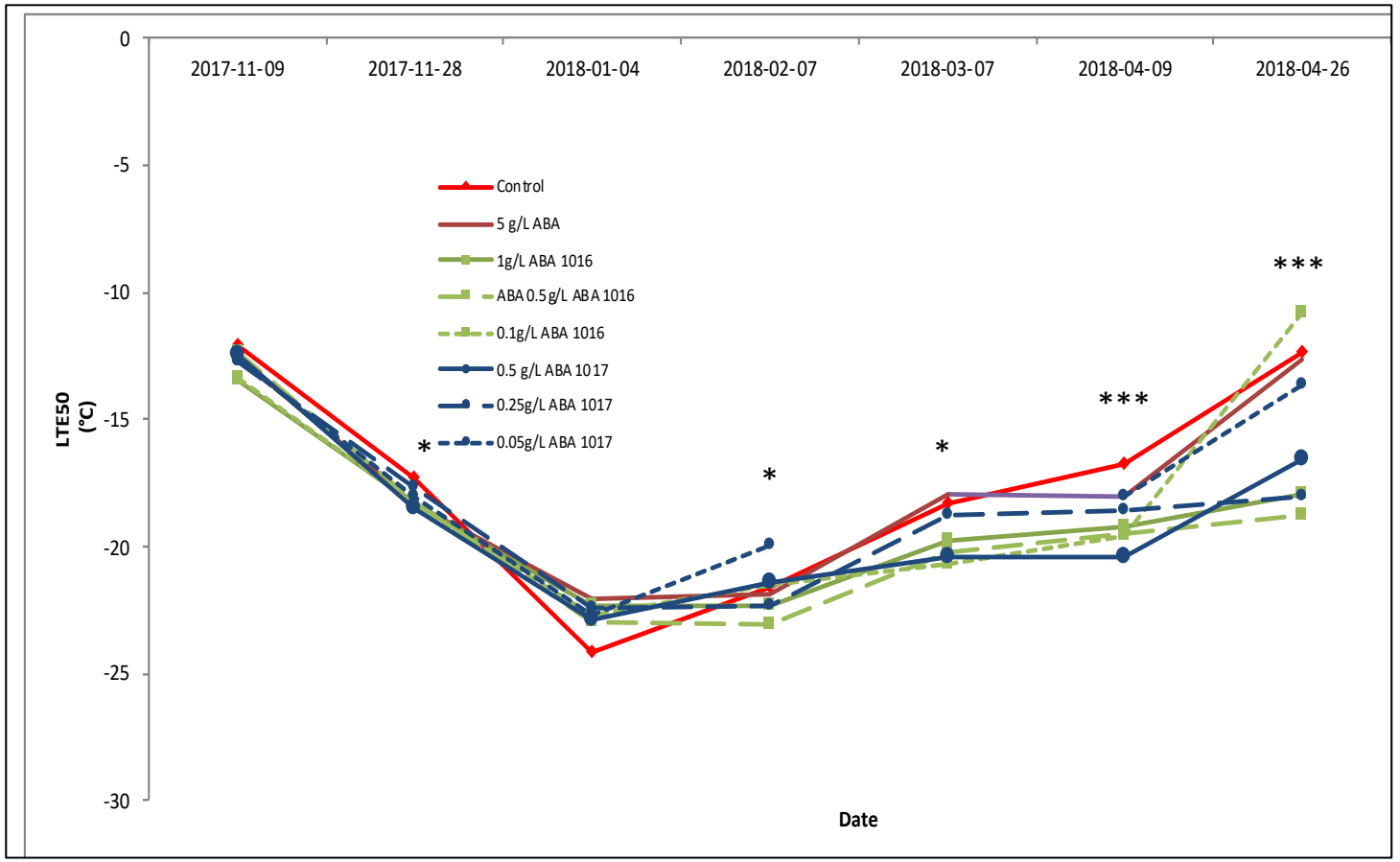


Figure 1. Cold hardiness dynamics of Merlot grapevines based on exogenous ABA treatments. Creek Shores, 2018. (*, ** represent statistical significance @ $p<0.05$, $p<0.001$, respectively)

Upcoming studies

- Funding through OGWRI to study in more detail how ABA analogs reduce the sensitivity of different V. vinifera cultivars from deacclimating
- Collaborating with Dr. Charles Despres on targeting key genes on treated and untreated grapevines
- This will further our understanding of ABA analog and improved hardiness at the molecular level

Adapting to climate change and improving sustainability through optimal vine selection

Cool Climate Oenology & Viticulture Institute

Brock University

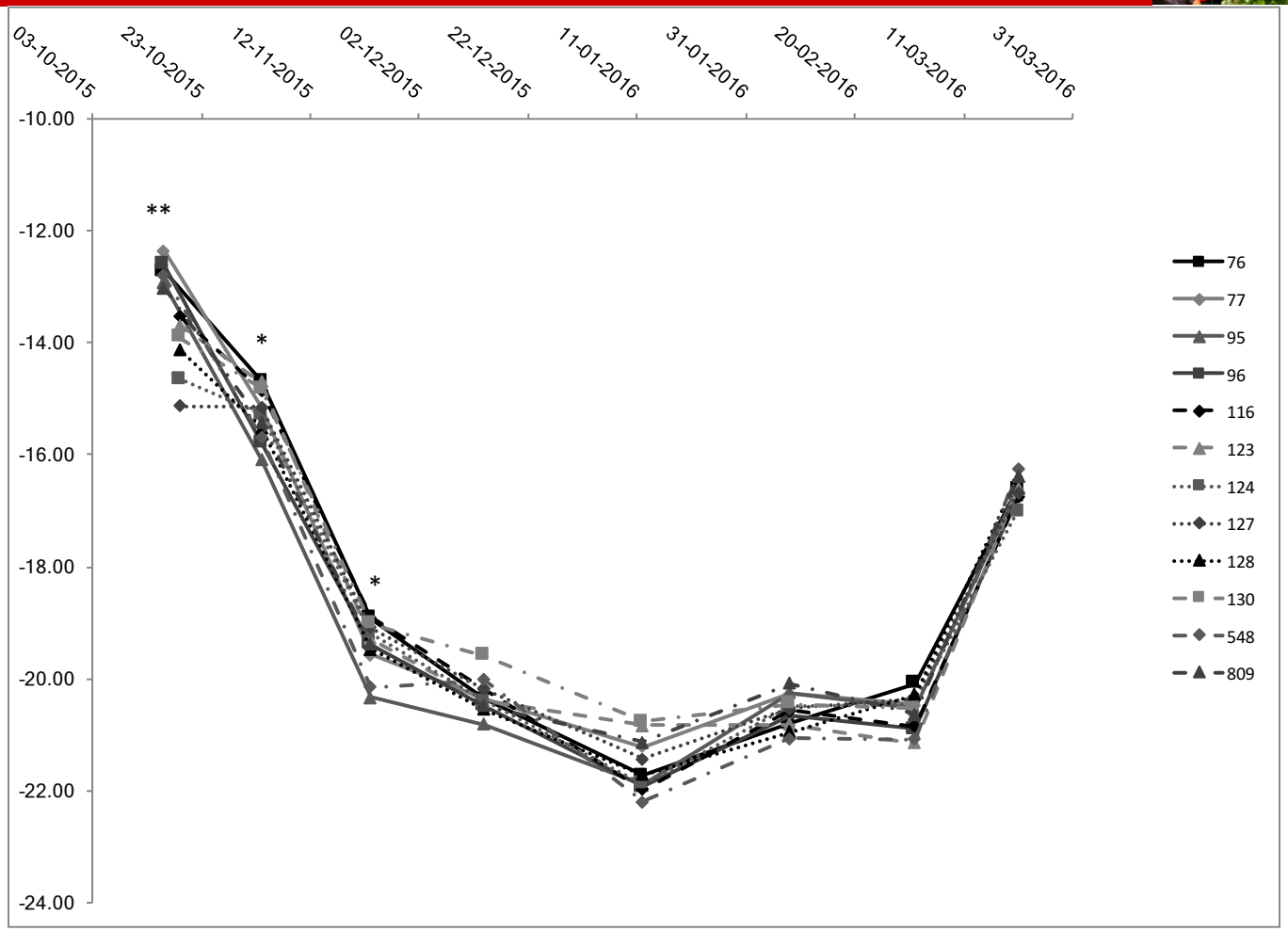
Evaluations for highest performing grapevine material

- **Industry is built on quality core *V. vinifera* cultivars**
- **After cold winters not all cultivars nor clones had similar survival rates**
  - Clone or rootstock related?
- **Need for formal evaluation programs to complement Canadian grapevine certification network**
- **Created research program to evaluate clones and rootstocks including formal experimental blocks**
- **“Vine to glass” approach**
- **Long term solution to mitigate climate change and continue to build quality and consistency of industry**

Cultivar x clone x rootstock evaluations

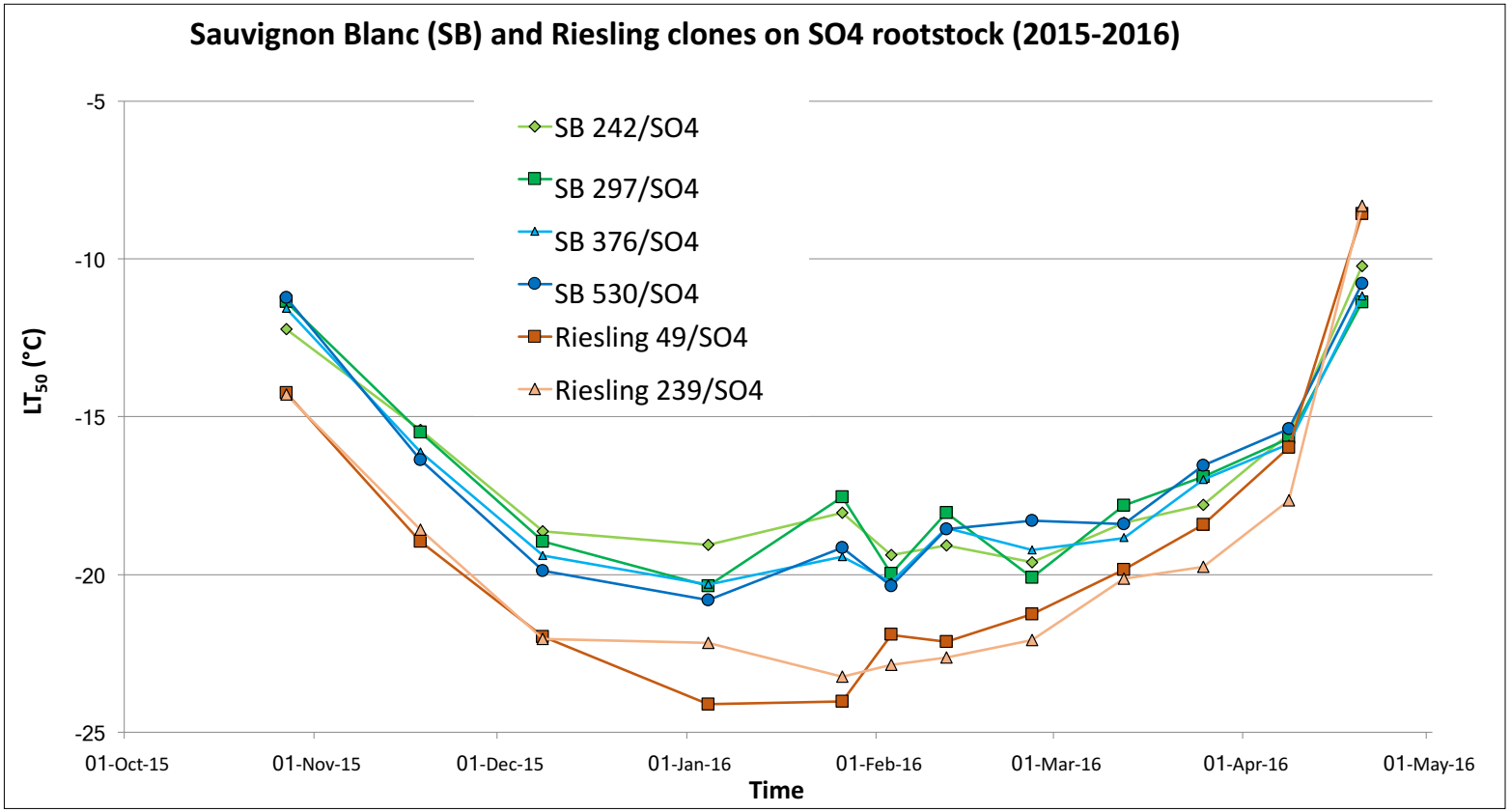
- Currently funded through OGWRI and NSERC-CRD (Inglis, Willwerth, Kemp)
- Industry partnerships for vineyard blocks
- Different soils, clones x rootstocks of core varieties

Cold hardiness in Chardonnay clones



Bud hardiness of 12 Chardonnay clones during dormancy. St. David's Bench. 2015-16.

Hardiness impacts of clones



Cold hardiness of Sauvignon blanc and Riesling clones grafted to SO4 rootstock. Four Mile Creek. 2015-16.

The next 5 years

- **AAFC funded $8.4 M to CGCN for their AgriScience Cluster program titled *"Fostering Sustainable Growth of the Canadian Grape and Wine sector"***

CANADIAN AGRICULTURAL PARTNERSHIP

Canadian Grapevine Certification Network

CGCN-RCCV

Réseau Canadien de Certification de la Vigne

Ontario GRAPE & WINE RESEARCH Incorporated

More research being conducted

- **Continuing to evaluate many of the varieties grown in Ontario for hardiness and understand environmental influences**
  - Help establish models of future trends in vine hardiness responses to climate
- **Vine performance, fruit quality and wine quality potential for clone x rootstock combinations**
- **Further evaluations and potential selections with greater resistance to freeze injury within core *V. Vinifera* varieties.**

AAFC Cluster Activity for the Canadian Grapevine Certification Network

“Grapevine evaluation and cold hardiness program to ensure superior plant material for the Canadian Grapevine Certification Network and to improve the sustainability of the Canadian Grape and Wine Industry”

Objectives

- **Key Objectives:**
- 1) To evaluate grapevine material for performance, cold tolerance and quality and improve the sustainability of the entire Grape and Wine Industry.
- 2) Assist with selection of superior plant material for the Canadian Grapevine Certification Network as well as future plantings across Ontario.

Acknowledgements

- CCOVI colleagues
  - D. Inglis, B. Kemp

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  - S. Bilek, M. Jasinski
- Graduate students
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- KCMS

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