Cool Climate Oenology & Viticulture Institute

Brock University

Getting Through the Winter: Updates on Freeze Protection and Cold Hardiness Research

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CCOVI, Brock University

CCOVI Lecture Series

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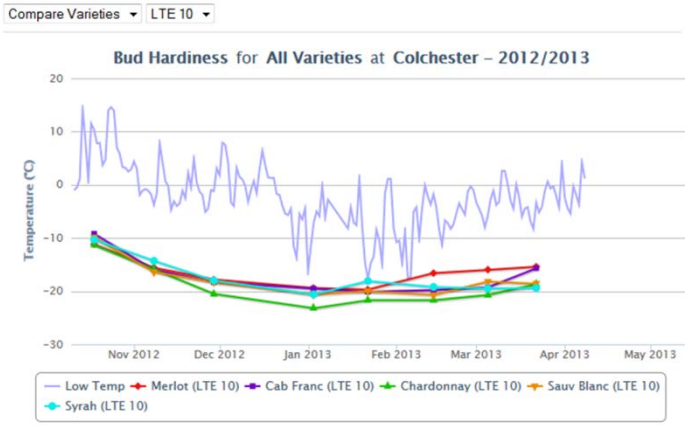
Overview

- Cold injury is a major contributor to economic loss due to poor yields, increased management costs and decreased fruit quality
- Research focused on cold hardiness identified as a priority by the grape and wine Industry

- Funding through AAFC - Developing Innovative Agri-Products initiative (DIAP), Ontario Ministry of Economic Development and Innovation's (MEDI) Ontario Research Fund (ORF).
- Collaboration between AAFC, MEDI, GGO, CCOVI

Grapevine Cold Hardiness Research

- *Vitis vinifera* wine grapes are not winter hardy
- Cold hardiness is limiting factor for growing many potential cultivars
- Need to understand important factors for our climate
- Optimization of cold hardiness to deal with cold winters and weather fluctuations during acclimation & deacclimation



Overall Objectives

- Monitor grapevine cold hardiness and create an advanced web-based database – VineAlert
- Further understand how to maximize grapevine cold hardiness and improve protection methods
- Impact of key vineyard management practices and understand the most critical factors involved
- Establish a grapevine cold hardiness ‘best practices’ guide for our climate

Freeze Injury

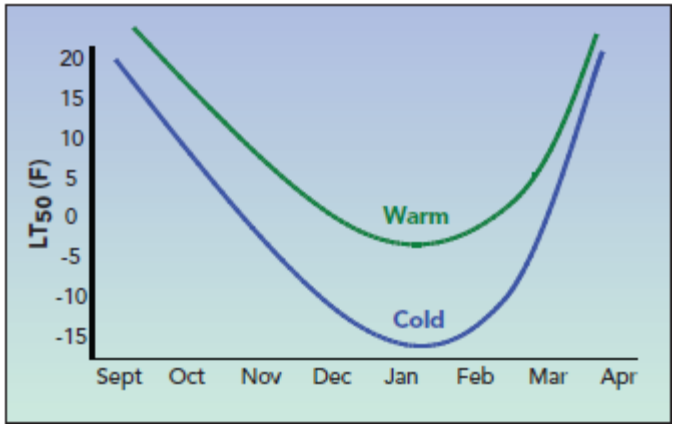
- Can occur during acclimation, mid-winter, deacclimation or post bud break
- Also associated costs of removing trunks/vines, renewing vines, replanting etc.

Consequences of cold injury

- Loss of fruiting buds
- Uneven or poor vegetative growth
- Inability to achieve vine balance
- Disease incidence (crown gall)
- Loss of uniformity
- Loss of consistency
- Loss of vines
- Ultimately reductions in yield, quality and $$$

What is Cold Hardiness?

- **Ability of plant tissue to survive freezing temperature stresses**
- **Very complex trait with many contributing factors**
- **Limited by inherent genetic potential**
  - *V. riparia* – 40C; *V. vinifera* -20's C
- **Influenced by environmental conditions**
- **Highly dynamic condition**



(MSU Extension Bulletin E2930, 2007)

Cold Hardiness: Dynamic condition

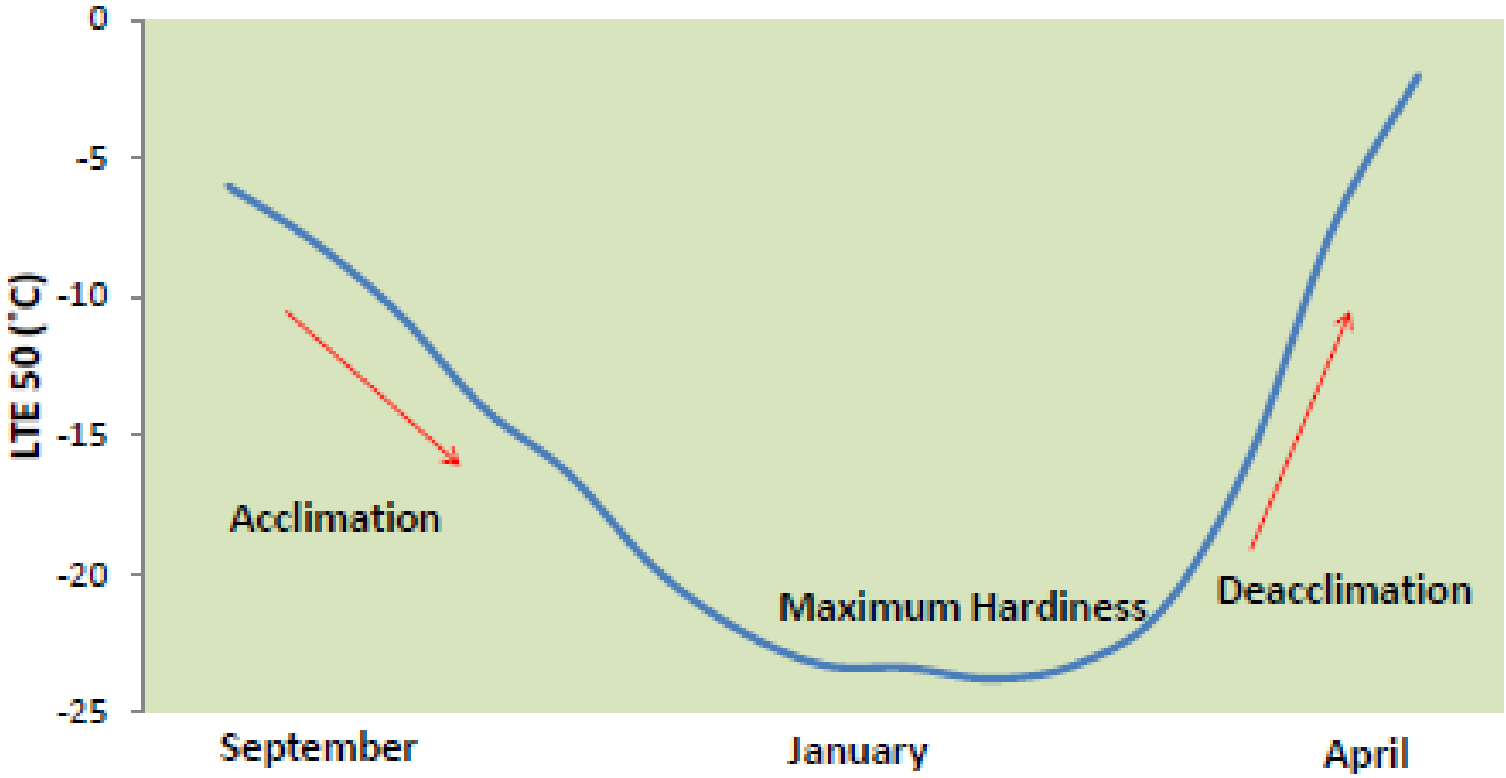
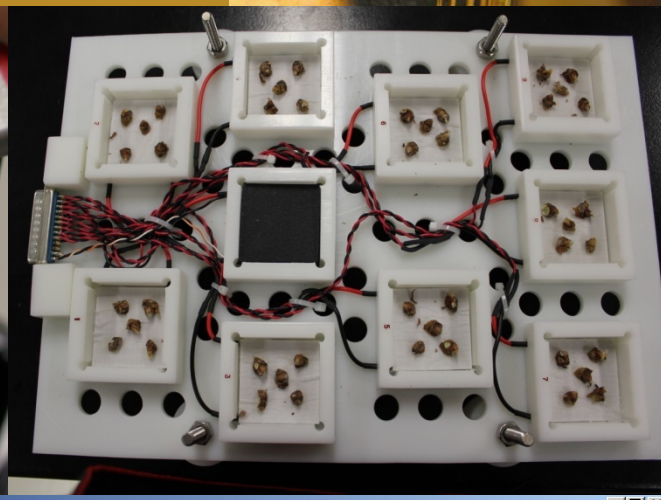
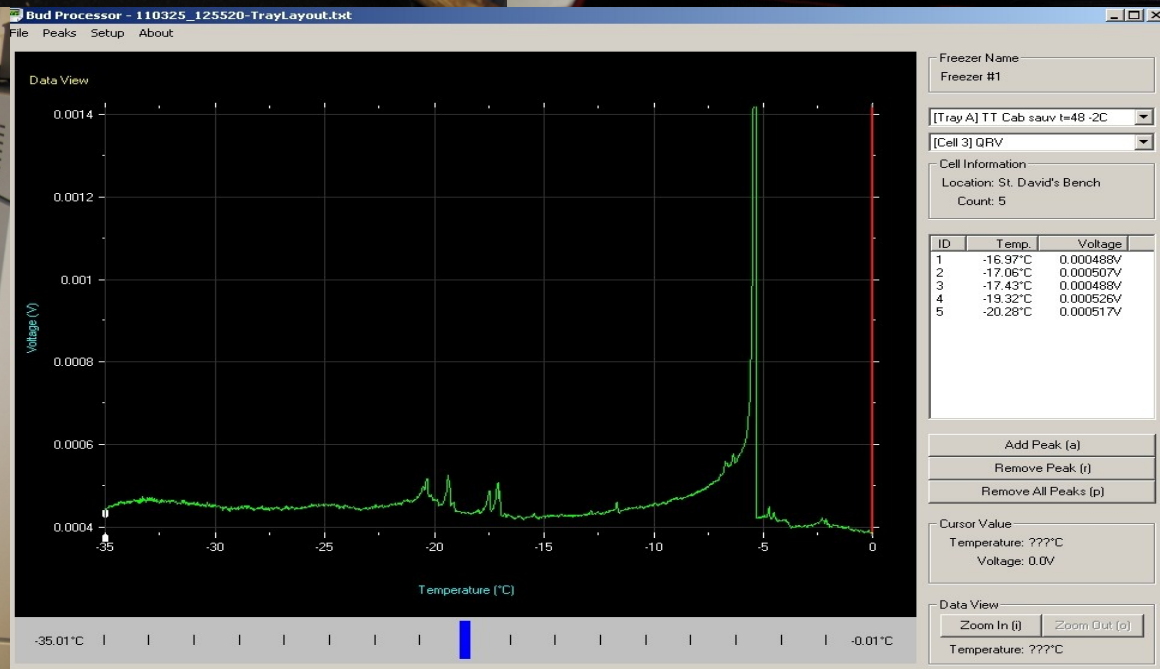


Figure 1. Profile of bud cold hardiness during the dormant season

(CCOVI VineAlert Website)

How we test cold hardiness - Differential Thermal Analysis (DTA)





Current studies concerning cold hardiness

- Regional sampling of bud hardiness across Ontario
- Assessing cold hardiness of different cultivars and locations
- Effects of crop level and harvest date
- Use of geotextile materials as a winter protection method
- Use of plant growth regulators to enhance dormancy and optimize cold hardiness
- Yield and vine water status studies
- Pruning strategies
- Examination of clone and rootstock effects
- Use of remote sensing and UAVs

Cultivar differences in cold tolerance

- Ontario alone grows over 32 varieties (VQA-approved)
- *V. vinifera (different groups of origin)*
- French hybrids
- New hybrids with extreme cold hardiness
- New cultivars to our region
- Variation within and between these categories

Cultivar differences in cold tolerance

- **Some key Cool Climate cultivars in Ontario**

Cultivar	DATE	LTE10	LTE50	LTE90
Riesling	07-Feb-13	-23.1	-24.4	-26.0
Chardonnay	14-Feb-13	-21.4	-23.9	-25.3
Pinot noir	14-Feb-13	-21.4	-22.9	-24.1

Cultivar differences in cold tolerance

Bordeaux varieties (2012/13)

Cultivar	DATE	LTE10	LTE50	LTE90
Malbec	07-Feb-13	-22.25	-23.7	-25.11
Petit verdot	07-Feb-13	-22.35	-23.99	-25.68
Cab Sauvignon	06-Feb-13	-21.64	-23.87	-24.97
Sauvignon blanc	14-Feb-13	-20.71	-22.03	-23.7
Merlot	05-Feb-13	-17.48	-20.08	-22.41
Cabernet franc	14-Feb-13	-21.32	-22.87	-24.25

Cultivar differences in cold tolerance

Other cultivars (2012/13)

Cultivar	DATE	LTE10	LTE50	LTE90
Gewurztraminer	07-Feb-13	-19.8	-22.6	-25.0
Semillon	07-Feb-13	-18.1	-21.4	-24.3
Tannat	07-Feb-13	-20.8	-22.5	-23.9
Tempranillo	07-Feb-13	-18.9	-21.9	-23.8
Viognier	07-Feb-13	-21.2	-23.8	-25.6
Sangiovese	07-Feb-13	-20.6	-21.9	-23.0
Auxerrois	22-Jan-13	-21.85	-24.3	-25.8

Cultivar differences in cold tolerance

Other cultivars (2012/13)

Cultivar	DATE	LTE10	LTE50	LTE90
Regent	14-Feb-13	-20.08	-22.99	-24.49
Bianca	14-Feb-13	-22.7	-24.19	-25.52
HG01	14-Feb-13	-22.12	-23.68	-24.94
Gr7	12-Feb-13	-22.12	-23.63	-24.81
Frontenac	12-Feb-13	-24.44	-26.31	-27.35
Sabrevois	12-Feb-13	-21.46	-22.54	-24.08
Marquette	12-Feb-13	-23.19	-25.32	-26.61

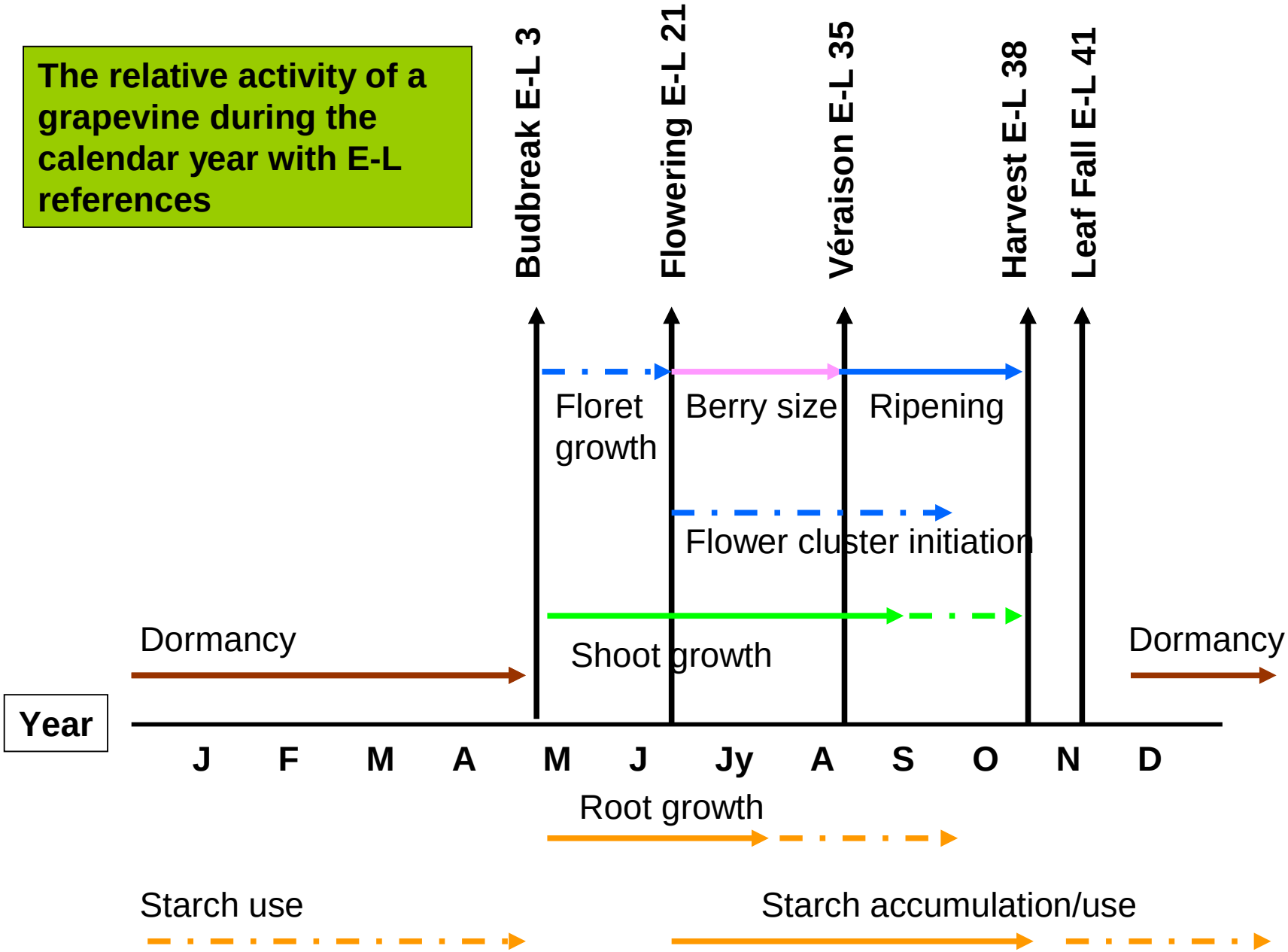
Crop level x harvest date trials

- **Heavy crop load can enhance the probability and severity of cold injury**
- **High crop levels can lead to poor acclimation and shoot maturation (Edson et al. 1995)**
- **Optimal crop levels can be cultivar and site specific**
  - Cluster thinning when warranted can improve hardiness and quality
  - Achieve balance between crop and vigour

Sources and sinks

- Leaf and shoot development is priority when vine is growing rapidly at beginning of season
- Young roots have priority in late spring and fruit development has priority in late summer
- As days get shorter, end of season – vine goes into storage mode – starch deposited in roots and trunk

The relative activity of a grapevine during the calendar year with E-L references



(Courtesy of K.H. Fisher)

Manipulation through crop levels

- By restricting growth, more energy can be diverted into fruit development
- Removal of fruit early encourages root development
- Too much fruit will restrict growth, root development
- If too much fruit left late in season, it will not mature and lead to poor reserves for overwintering success
- Everything is interconnected!

Timing of harvest

Factor for late ripening cultivars

- **Important in cool climate regions like Ontario**
- **Later harvest delays cold hardiness?**

- **Crop levels/timing of harvest is a factor for different wine styles in Ontario**
- **Early - Sparkling**
- **Normal - Table**
- **Late – Late harvest, Icewine, "Appassimento-style"**
  - Can be cropped heavier as well

Experimental design

- Studying the impact of Crop level x harvest date
- 2 cropping levels (full and ½) x different harvest dates (early and late)

Cultivars:

Riesling, Sauvignon blanc, Cabernet franc, Pinot noir, Chardonnay

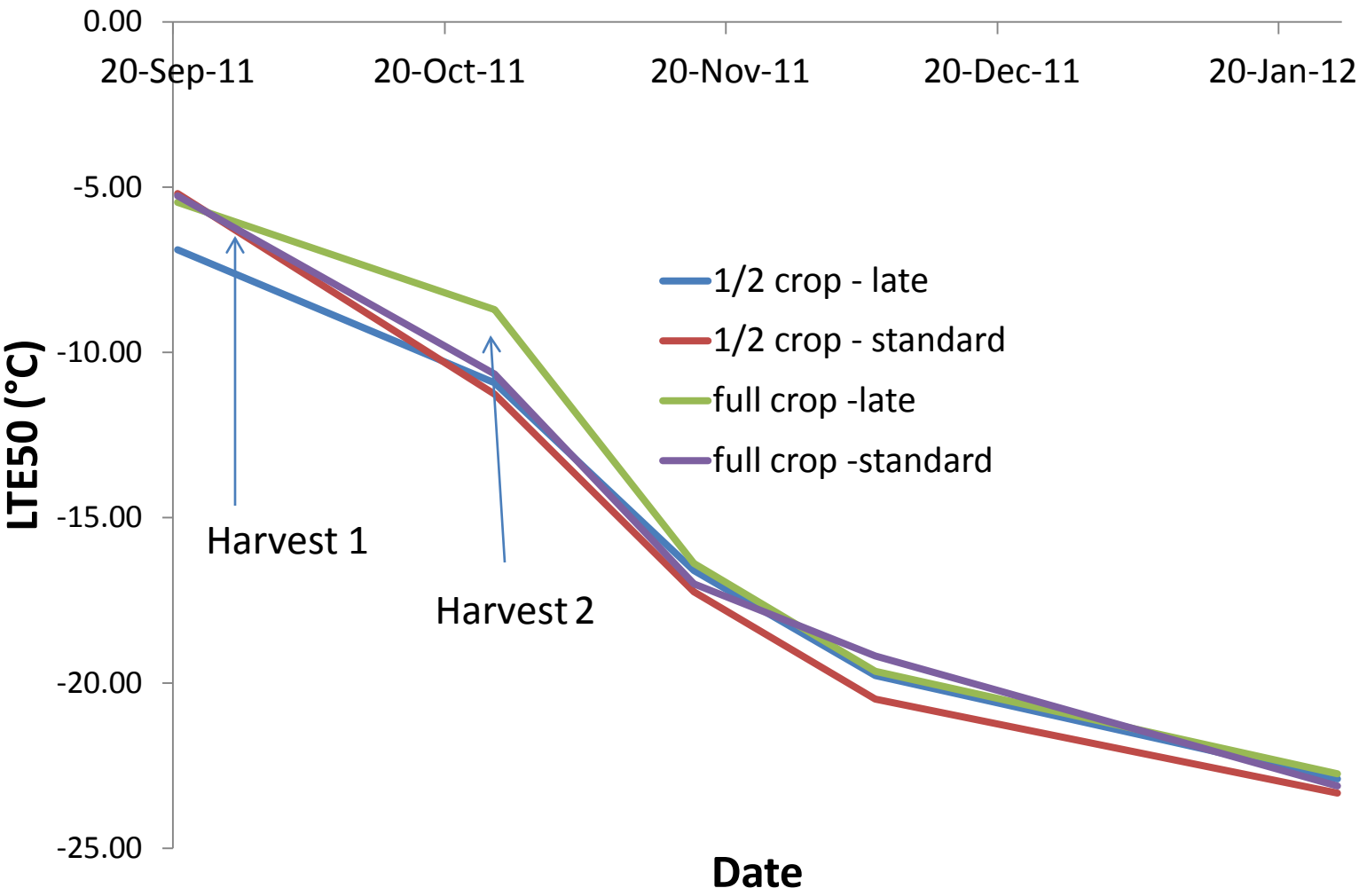
- Randomized complete block designs, 6 replicated blocks containing each combination
- Blocks located in Vineland and Niagara on the Lake

Harvest times – Normal harvest at commercial maturity levels and later harvest 3 weeks later

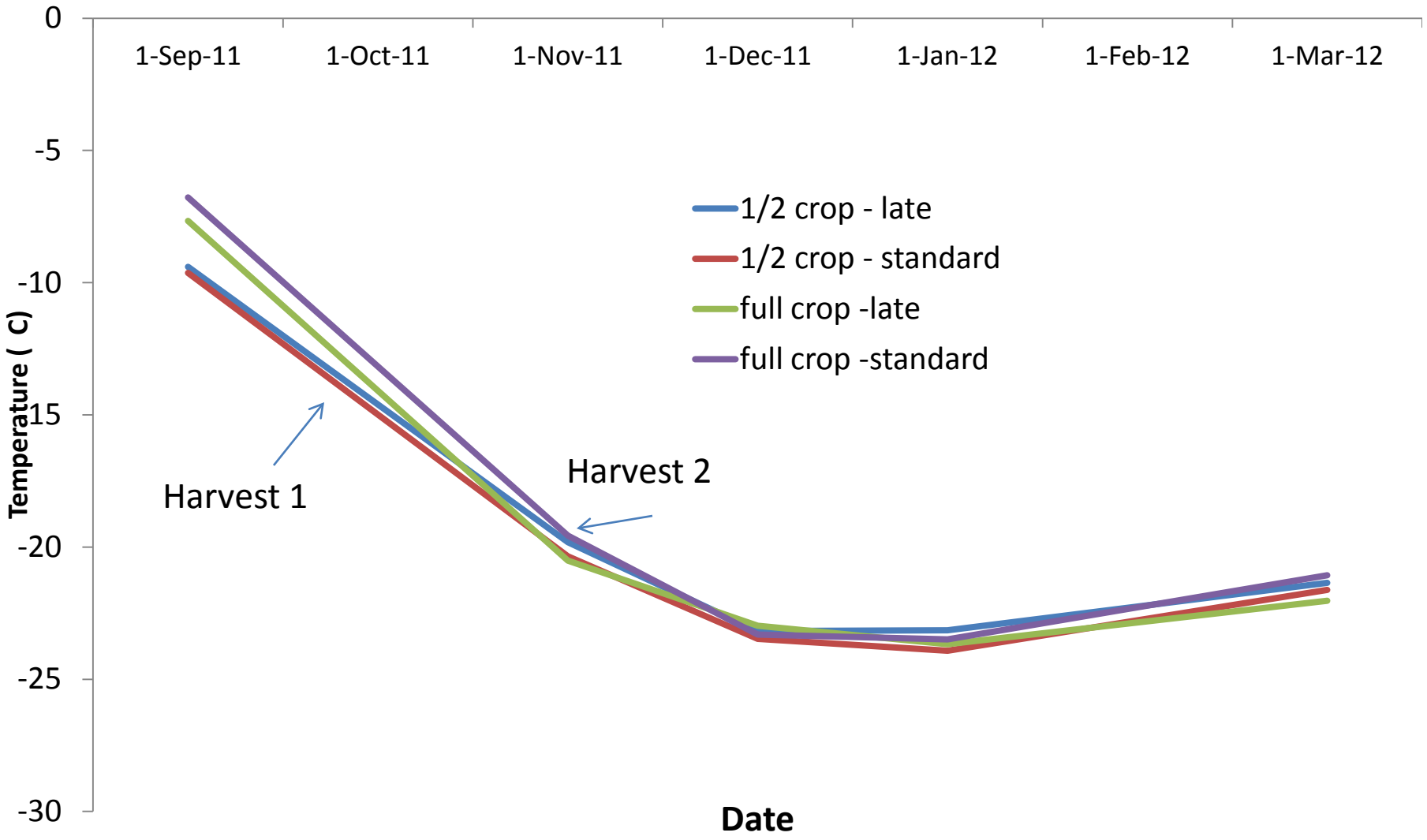
Crop level/harvest date studies
Sauvignon blanc – Acclimation -2011

Date	Treatment	LTE10	LTE50	LTE90
	Half crop/late	-4.3	-6.9	-8.4
20-Sep-11	Half crop/standard	-3.9	-5.2	-7.0
	Full crop/late	-4.9	-5.5	-6.1
	Full crop/standard	-3.6	-5.3	-8.5
	Half crop/late	-6.8	-10.9	-12.3
25-Oct-11	Half crop/standard	-9.4	-11.3	-13.0
	Full crop/late	-5.4	-8.7	-9.8
	Full crop/standard	-5.3	-10.7	-11.7
	Half crop/late	-14.9	-16.6	-17.8
16-Nov-11	Half crop/standard	-16.1	-17.2	-18.6
	Full crop/late	-14.7	-16.4	-18.2
	Full crop/standard	-15.1	-17.0	-18.9

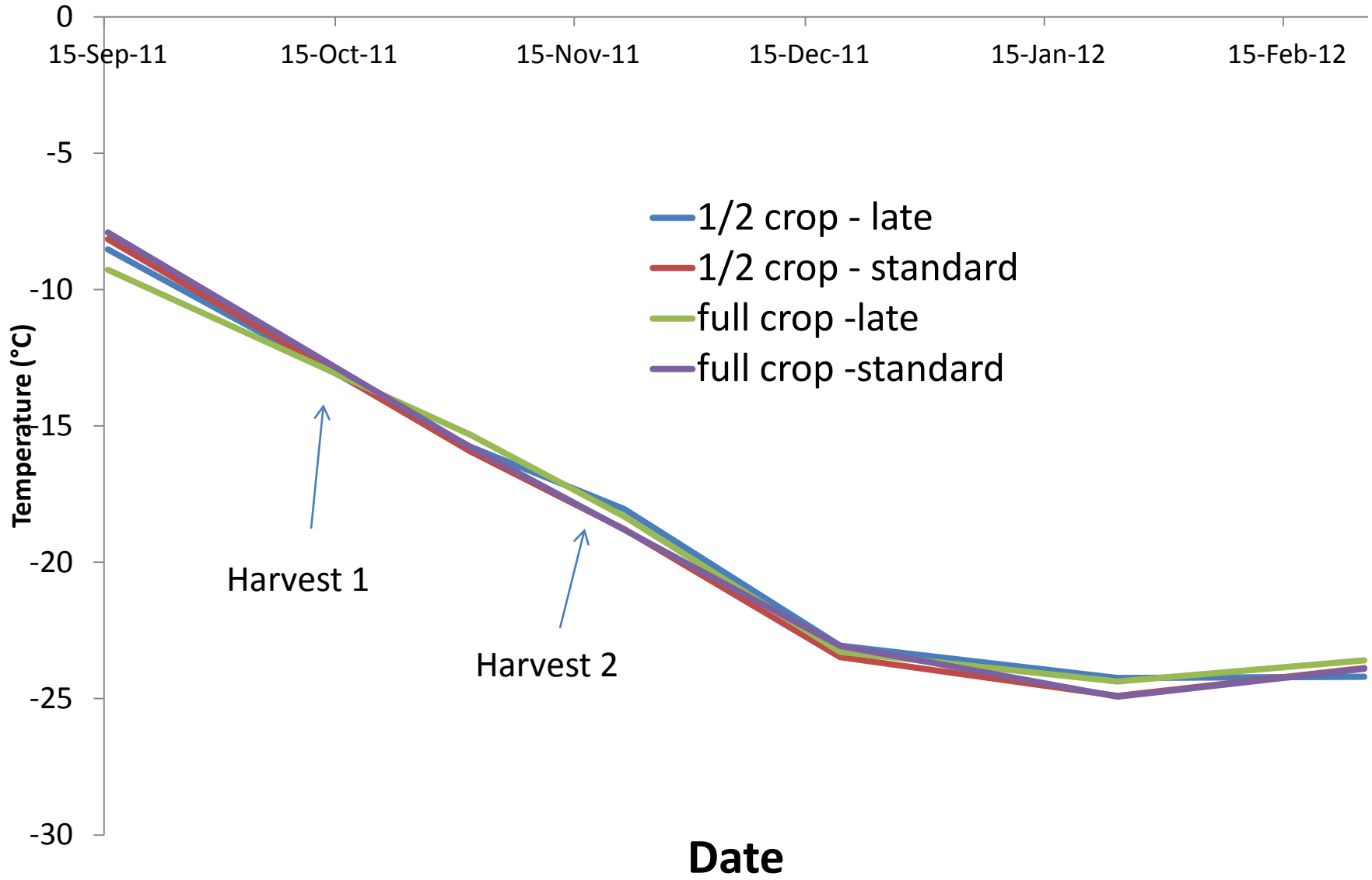
Impact of Crop level and harvest date Sauvignon blanc: Acclimation (2011)



Pinot noir LTE 50 - 2011/12



Impact of Crop level and harvest date Riesling (2011/12)



Yields and fruit composition for 1st harvest (2012)

Variety	Crop Level	# Clusters	Yield (kg)	Vine Size (kg)	Berry Weight (g)	Brix	Titratable Acidity (g/L)	pH
Sauvignon blanc	Full	23	3.8	-	1.312	23.6	5.97	3.49
	Half	15	2.2	-	1.301	25.2	5.94	3.53
Riesling	Full	39	4.4	0.56	1.297	18.4	10.41	3.29
	Half	20	2.5	0.40	1.441	19.3	9.34	3.37
Chardonnay	Full	26	3.6	0.16	1.235	17.9	8.98	3.53
	Half	18	2.4	0.15	1.272	19.0	8.40	3.54
Pinot noir	Full	15	2.2	0.42	1.231	21.2	7.76	3.59
	Half	10	1.3	0.36	1.225	21.0	7.65	3.60
Cabernet franc	Full	24	3.0	0.22	1.215	19.5	5.64	3.67
	Half	16	1.8	0.21	1.224	19.0	5.87	3.67

Results to date - Crop level x harvest date

- **Crop level appears to have some effects on cold hardiness dynamics**
  - more during acclimation but some mid to late winter differences in 2012/13
- **Harvest date has less of an impact but an early harvest can lead to quicker acclimation**

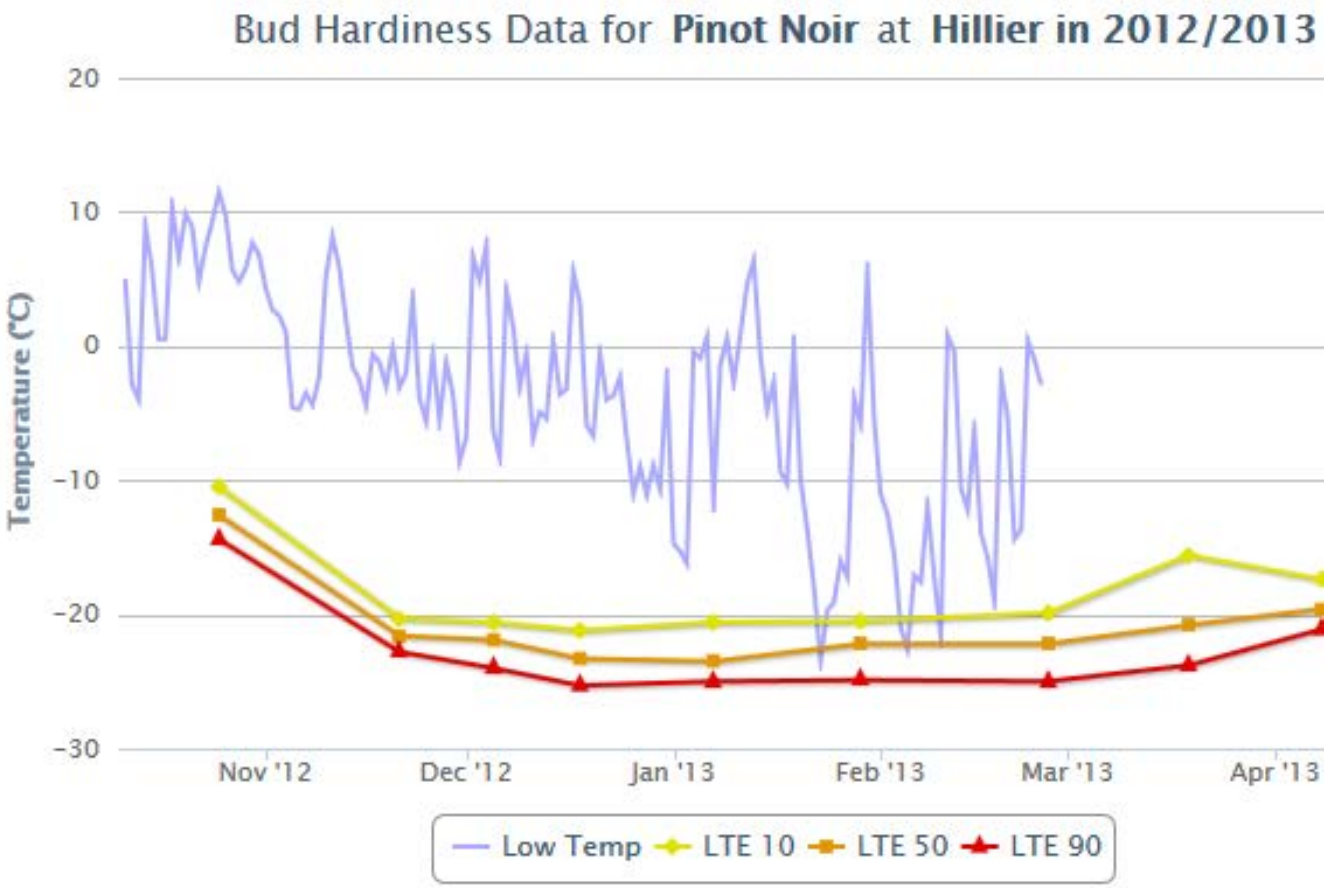
- **Some observations of early to bed – early to rise –**
  - Treatments that acclimated earlier or didn't get as hardy appear to be deacclimating first
- **Vintage differences especially with early harvest in 2012**

Thoughts so far – crop level/harvest date studies

- Crop thinning impacts yields and fruit quality
- Later harvests associated with higher SS, lower TA, higher pH
- Varietal responses? Some may be impacted more than others under our climate conditions (even with small yield differences)
- Growing season and vintage differences?
- Heavier crop levels may have a greater impact

Use of Geotextiles for winter protection

- **The need for protection**



Use of Geotextiles for winter protection

- **Geotextiles are materials used for winter protection of crops**
- **Used in Quebec vineyards**
- **Interest in Ontario vineyards have increased as of late**
- **Why?**
  - *Vinifera* need protection in some areas
  - Concern about damaging soils
  - Concern about damaging buds
  - Bud rot/loss
  - POOR YIELDS
  - Timing and weather

Buried canes - research from Cornell (Goffinet 2005-06)

- Experiment inspired by the severe winter injuries of 04-05
- Bud survival measured on both buried and aerial canes of Gewürztraminer, Pinot Gris and Cabernet
- Aerial canes in general proved more cold-hardy than buried canes, and buried canes experienced delayed shoot development once they were unburied
- Temperatures were relatively mild.

Evolution of research

- **Determined that there was a need to study these materials in Ontario vineyards**
- **Research Questions**
  - How effective are these materials at mitigating damaging cold temperatures?
  - Do these materials cause a 'greenhouse effect'?
  - What impact is there on bud hardiness and survival?

- **Help determine 'best practices'**
- **Study in Prince Edward County**
  - Sugarbush vineyards with Margaret Appleby (OMAF and RA)
  - Geotextile: Hibertex Pro, Dubois Agrinovation

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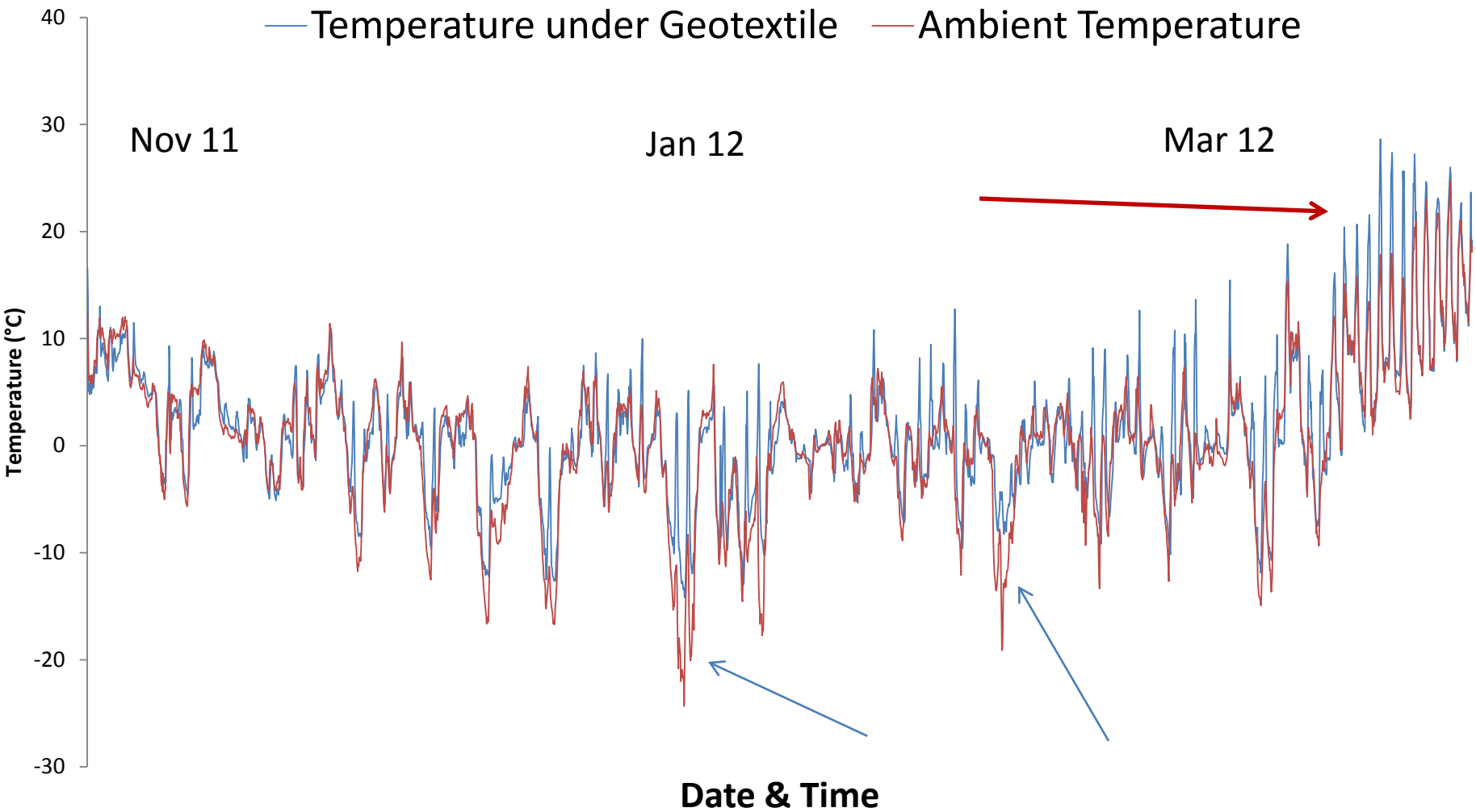
Geotextile experiment I

- 8 panels of vines under textile
- Randomized within Chardonnay block
- 2 methods
- Textile above laid down canes on low wire
- Textile tented above spur pruned vine
- Temperature recorded under geotextile and ambient temperature
- Buds sampled for cold hardiness

Impact of Geotextiles on temperature



Impact of geotextiles on bud hardiness

Treatment	Date	LTE10	LTE50	LTE90
	13-Dec-11	-18.7	-22.04	-23.53
Aerial canes	18-Jan-12	-20.7	-23.4	-25.2
	29-Feb-12	-21.4	-22.64	-23.58
	27-Mar-12	-6.9	-11.1	-13.1
Treatment	Date	LTE10	LTE50	LTE90
	13-Dec-11	-18.63	-21.35	-23.11
Geotextile	18-Jan-12	-16.72	-22.81	-24.52
	29-Feb-12	-20.8	-22.32	-23.57
	27-Mar-12	-6.7	-11.4	-13.5

Other findings from last year

- Materials were removed mid-March during warm period
- Vines unearthed shortly after
- Cold temperatures (-6) at end of April killed many primary buds
- Interesting observation was that panels covered with geotextile had 100% crop compared to buried vines which had around 20-30% of a normal crop at harvest

Geotextiles II
The Expanded Study (2012-)

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- **Two types of materials**
  - White Polyester felt
  - White Polyester felt with black LDPE
- **Different timings of removal**
  - Beginning of deacclimation (March)
  - Mid to end of deacclimation (April)
- **Compared to burying of vines and control**
- **Two Locations – PEC and Vineland**
- **Two cultivars – Chardonnay and Pinot noir**
- **Temperatures monitored using dataloggers**

The materials

Canes tied below materials

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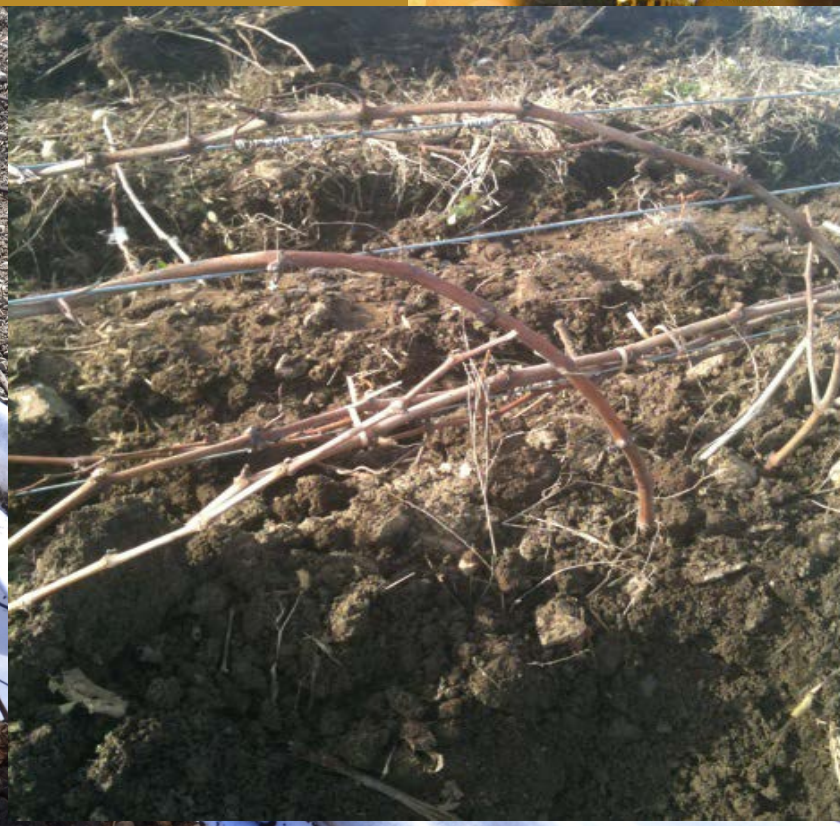

Temperatures during acclimation to mid-winter using different grapevine protection methods within Prince Edward County. Wellington, ON. (2012-13).

November (last 2 weeks of the month)				
	Ambient	Polyester felt	Polyester felt with black LDPE	Under Soil
Monthly mean temperature (°C)	1.01	1.14	1.15	1.76
Absolute Maximum temperature (°C)	12.10	16.54	13.79	9.63
Absolute Minimum temperature(°C)	-8.67	-7.27	-5.95	-2.95
December				
	Ambient	Polyester felt	Polyester felt with black LDPE	Under Soil
Monthly mean temperature (°C)	-0.26	-1.57	0.53	1.22
Absolute Maximum temperature (°C)	15.34	9.26	14.7	10.54
Absolute Minimum temperature(°C)	-11.33	-6.55	-6.99	-3.07
January				
	Ambient	Polyester felt	Polyester felt with black LDPE	Under Soil
Monthly mean temperature (°C)	-3.47	-2.96	-2.78	-1.54
Absolute Maximum temperature (°C)	13.38	17.42	16.37	8.74
Absolute Minimum temperature(°C)	-23.41	-19.07	-19.38	-10.27

Acclimation and Mid-Winter Hardiness levels

Chardonnay								
Treatment	Date	LTE10	LTE50	LTE90	Date	LTE10	LTE50	LTE90
Control	05-Dec-12	-21.37	-23.38	-25.15	29-Jan-13	-17.81	-23.75	-25.58
Polyester felt with black LDPE	05-Dec-12	-20.7	-22.56	-25.19	29-Jan-13	-17.54	-23.73	-26.29
Polyester felt	05-Dec-12	-17.81	-21.69	-23.64	29-Jan-13	-20.49	-23.84	-25.79
	Pinot Noir							
Treatment	Date	LTE10	LTE50	LTE90	Date	LTE10	LTE50	LTE90
Control	05-Dec-12	-19.35	-23.31	-25.01	29-Jan-13	-19.14	-24.55	-26.25
Polyester felt with black LDPE	05-Dec-12	-19.98	-22.57	-24.09	29-Jan-13	-18.79	-24.01	-26.12
Polyester felt	05-Dec-12	-20.54	-22.63	-24.14	29-Jan-13	-22.57	-24.79	-25.89

Table 3. Predicted grapevine bud cold hardiness ratings for Chardonnay and Pinot noir using different protection strategies within Prince Edward County. Wellington, ON. (2012-13).

Vine microclimate temperatures during mid to late winter months using different grapevine protection methods within Prince Edward County. Wellington, ON. (2012-13).

February				
	Ambient	Polyester felt	Polyester felt with black LDPE	Under Soil
Monthly mean temperature (°C)	-6.54	-3.74	-3.16	-1.52
Absolute Maximum temperature (°C)	5.54	6.84	5.95	-0.09
Absolute Minimum temperature(°C)	-25.38	-17.64	-13.97	-6.52
March				
	Ambient	Polyester felt	Polyester felt with black LDPE	Under Soil
Monthly mean temperature (°C)	-1.269	-0.558	-0.248	-0.338
Absolute Maximum temperature (°C)	11.297	10.687	13.185	3.142
Absolute Minimum temperature(°C)	-11.79	-9.47	-11.11	-3.48

Temperatures during dormant period

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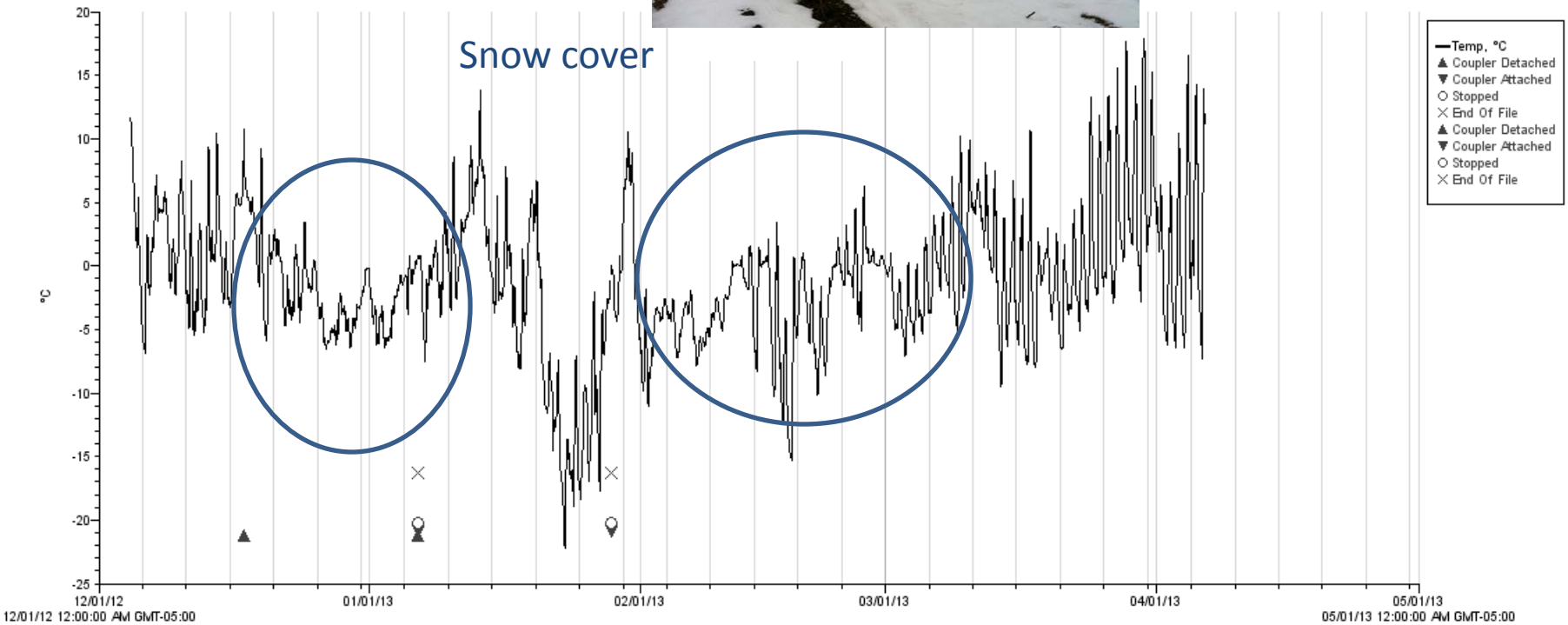


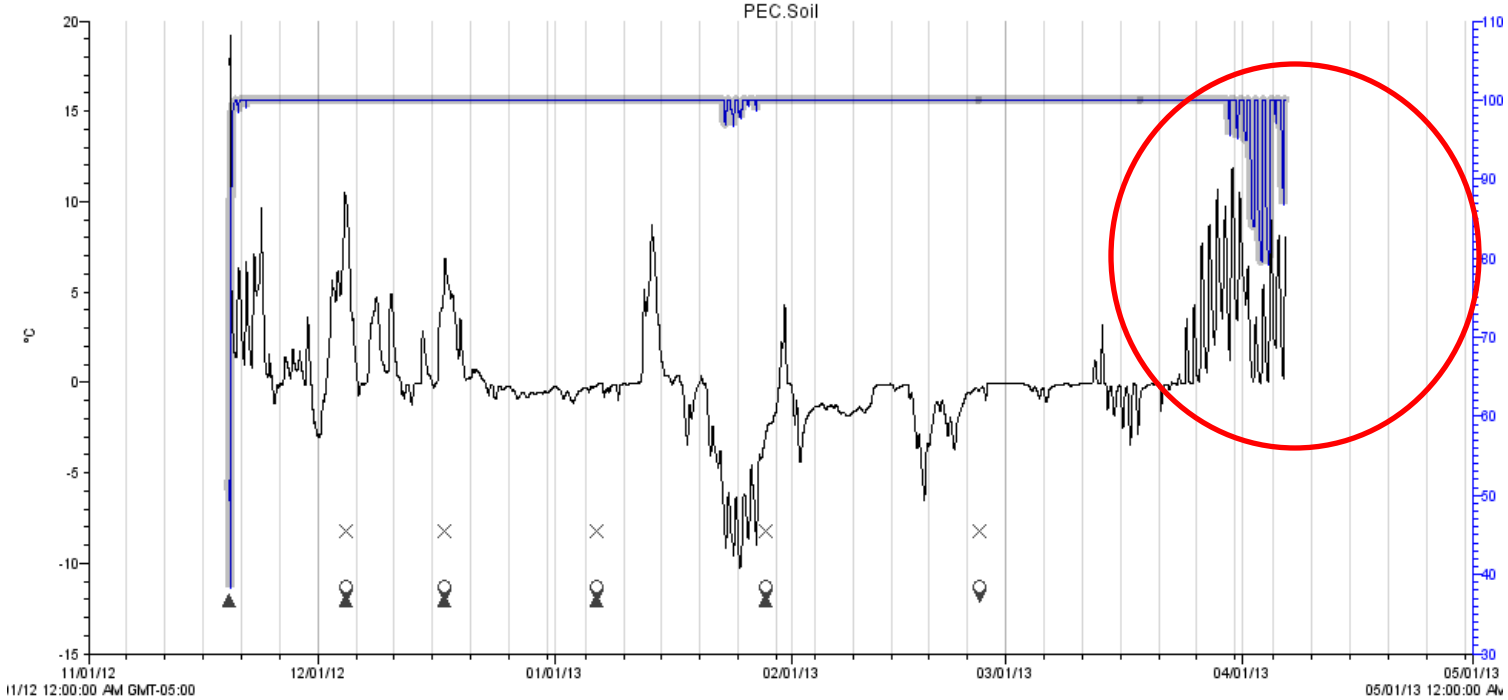
Late winter hardiness levels - deacclimation

Chardonnay				
Treatment	Date	LTE10	LTE50	LTE90
Control	08-Apr-13	-16.26	-18.2	-20.77
Polyester felt with black LDPE (removed)	08-Apr-13	-15.08	-17.36	-20.24
Polyester felt with black LDPE	08-Apr-13	-13.95	-16.83	-20.04
Polyester felt (removed)	08-Apr-13	-16.45	-18.57	-20.41
Polyester felt	08-Apr-13	-14.28	-15.48	-17.52

Predicted grapevine bud cold hardiness ratings for Chardonnay and Pinot noir using different protection strategies within Prince Edward County. Wellington, ON. (2012-13).

What lies Beneath?

- Most interesting story may be what is happening below soil with warmer temps
- Vines will be unearthed and examined for cold hardiness next round of sampling



Preliminary observations and thoughts

- **Geotextiles do moderate minimum temperature extremes (Bud survival near 100%, <40% above ground)**
- **Snow cover remains on vines longer with white geotextiles than buried vines**
  - This improves hardiness and temperature moderations
- **Materials can improve cold hardiness at certain times of year**
- **Some impact on bud hardiness (maximum)**

Preliminary observations and thoughts

- **Greenhouse effects when soils are warmer (fall, late winter/spring)**
- **Timing and removal of application**
  - Implications if too early or too late
- **Logistics**
- **Economics**

  cost factors and durability
- **Another factor that has appeared in some areas…..**

CURRENT STATE OF THE VINES: Summary of fall 2012 to present

- Exceptional growing season
- Early harvests and periderm formation
- Vines acclimated at an average rate and similar to 2010
- Some fluctuations during winter
  - 15 to -15C and some cold events late in January and early-mid Feb.
- Bud survival rates high
- Colder (more normal) spring resulted in slow deacclimation so far but vines are losing tolerance now at a faster rate
- Vine tolerance in -10.5 to -16 C range

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

- **Our advanced cold hardiness database and alerting system during periods of risk**

Vine Alert: Overview

Grapevine management and monitoring system for cold hardiness and injury.

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

Grapevine Bud Cold Hardiness Database

Overview

Welcome to the Ontario regional grapevine bud cold hardiness webpage. The information contained on this webpage is to provide grape growers with comparative levels of bud hardiness for cultivars at different locations throughout the dormant period. Monitoring bud cold hardiness throughout the dormant period is an invaluable tool to assist grape growers in managing winter injury. The data provided from this database will allow growers and researchers to see how cold-hardy grapevines are within a specific area. Cold hardiness is **not static** but varies throughout the dormant period and is determined through the grapevine's genetic potential and environmental conditions. Therefore, grapevine species and cultivars vary in terms of their cold hardiness. Bud sampling and testing will be done throughout the entire dormant season to monitor cold hardiness through the acclimation, maximum hardiness, and deacclimation periods. This ever-changing bud hardiness data can be helpful in determining when wind machine use or other freeze avoidance methods are warranted to protect the vines from winter injury.

Yearly cold hardiness dynamics – Chardonnay (Four Mile Creek)

Location: Niagara Peninsula | Four Mile Creek | Use Map »

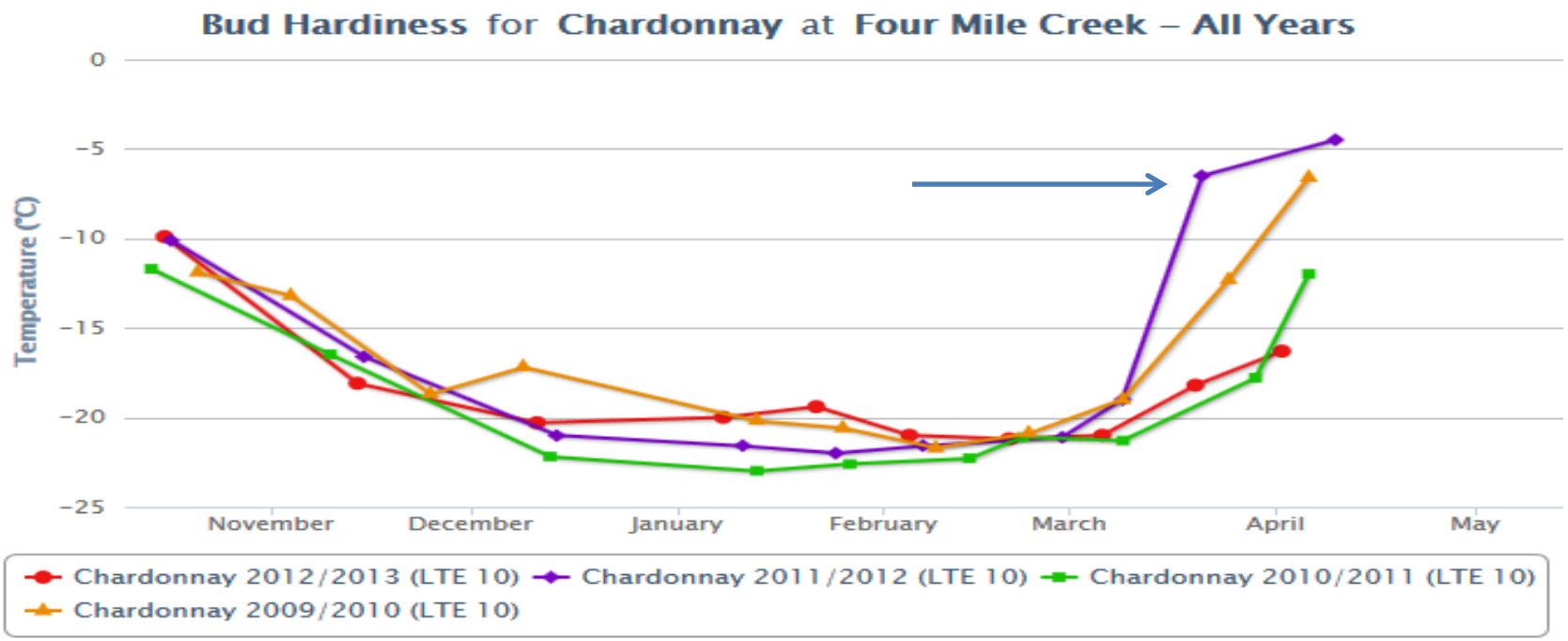
Variety: Chardonnay

Year: All Selected

View Most Recent Data across all Varieties and Locations »

Table | Comparison-Table | Chart | Comparison-Chart

Compare Years | LTE 10



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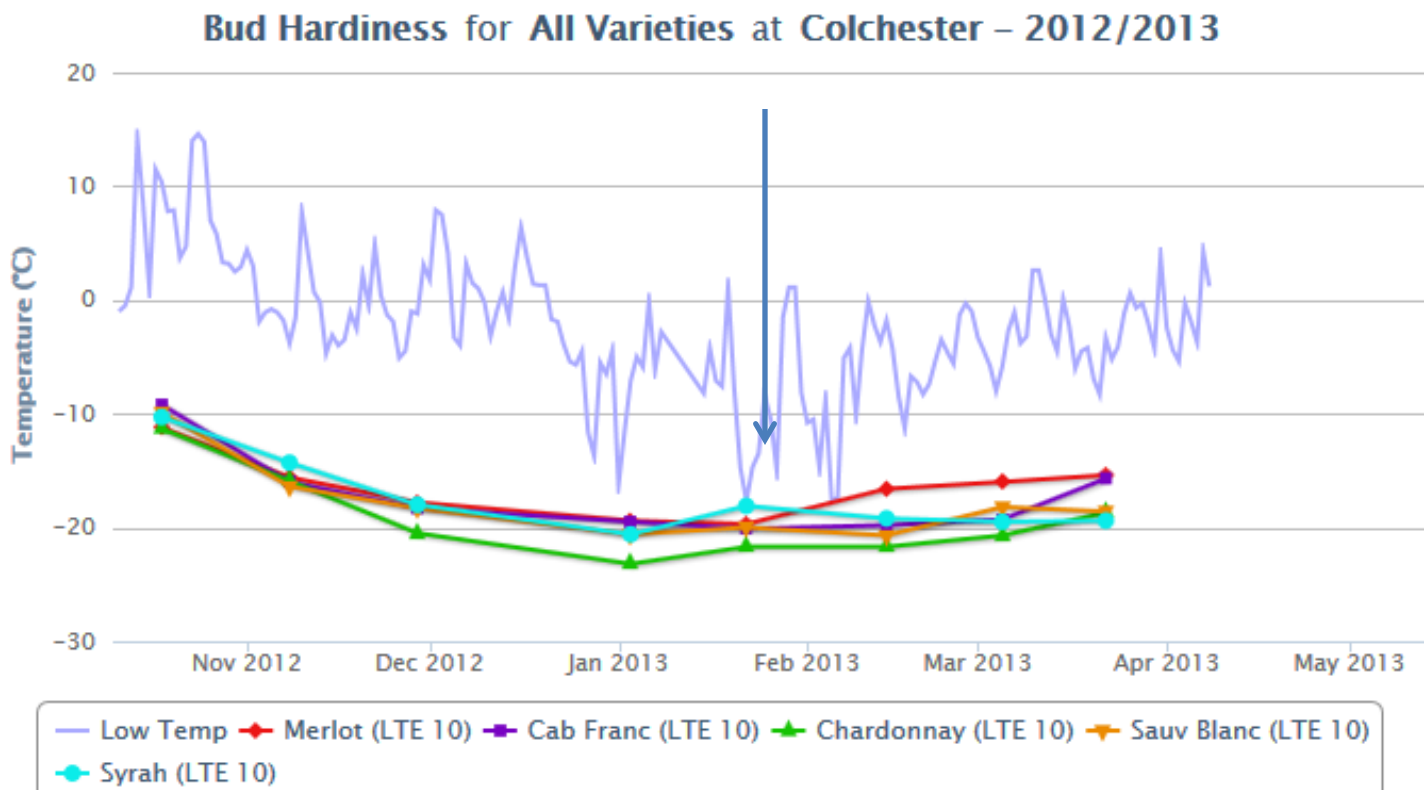
Variety cold hardiness profiles – 2012/13, Colchester, LENS

Compare Varieties | LTE 10



Bud Survival Data for **Syrah** at **Colchester in 2012/2013**

Edit	Sampling Date	Survival Rate (%)
Edit	February 14, 2013	72.0
Edit	January 3, 2013	95.0

Bud Survival Data for **Merlot** at **Colchester in 2012/2013**

Edit	Sampling Date	Survival Rate (%)
Edit	February 14, 2013	89.0
Edit	January 3, 2013	95.0

Conclusions and final thoughts

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- Cold Injury is a major threat to the grape and tender fruit sectors
- Understanding how to get optimal vine hardiness and the best winter protection
- Critical for vine balance, uniformity, consistency and ultimately quality

Conceptual view of vineyard factors impacting wine quality (Reynolds, 2000)

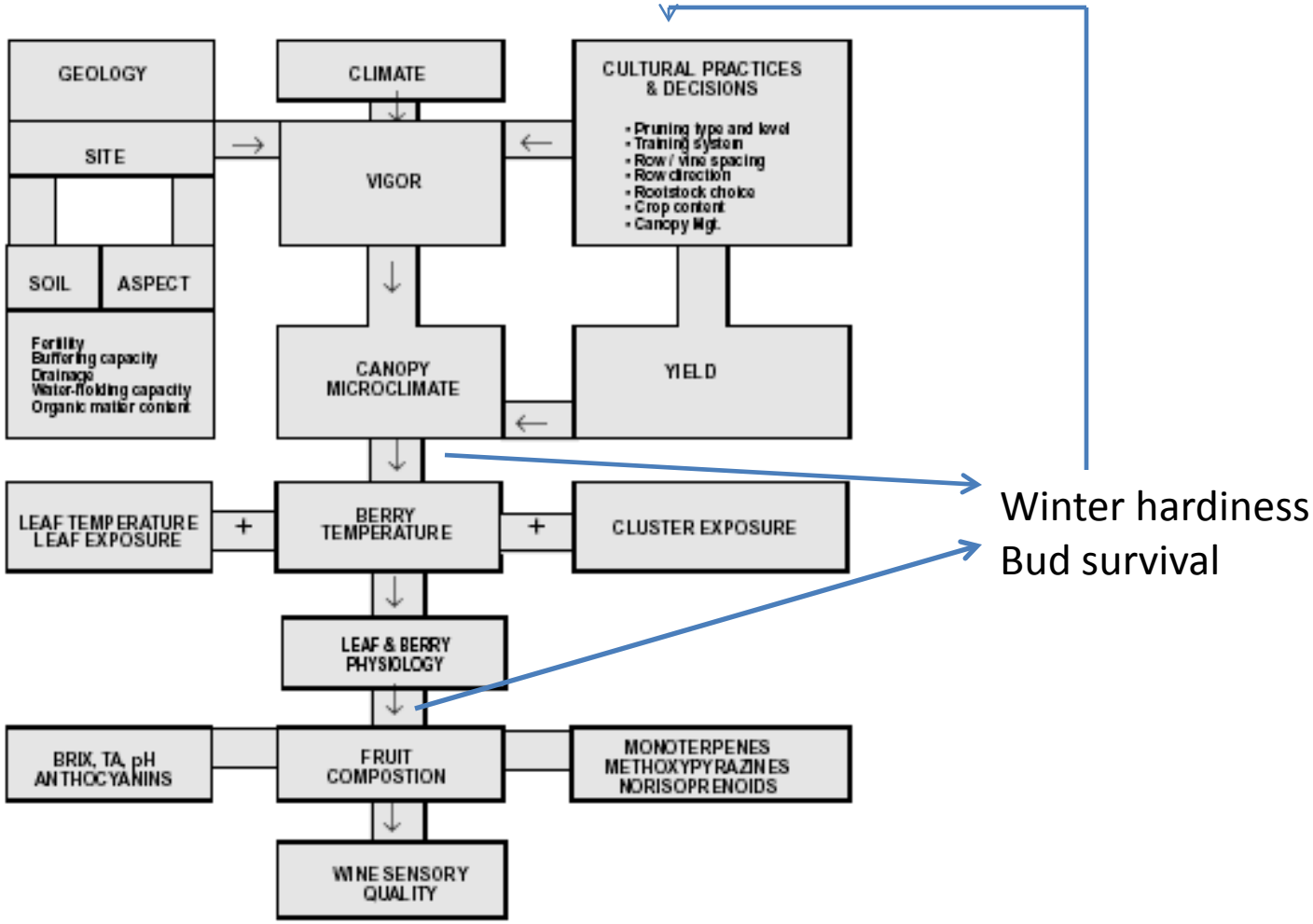
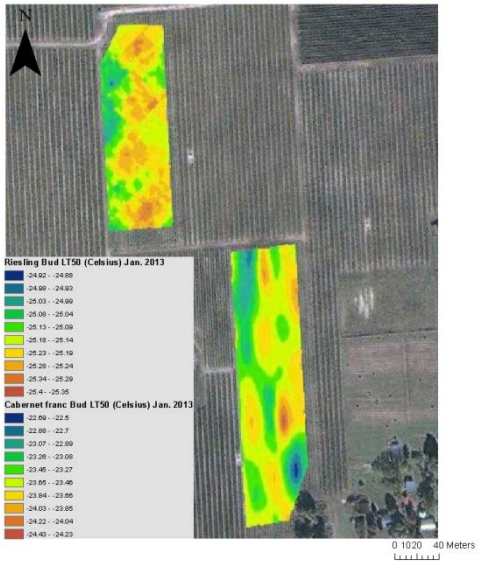


Fig. 1. A conceptual view of factors contributing to vine balance and wine quality. Modified from Smart *et al.* [34].

Conclusion

- Research (experimentation), outreach, innovation are key to success for pushing boundaries, improving quality and profits
- Looking forward - weather extremes, water, etc…….
- At one point no one thought wind machines would help so much….what's next????



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Cold hardiness testing – research only (does not include regional sampling!)

- # of projects – 9
- # of varieties tested – >32
- Locations – 16
- # of freezer units – 3
- Buds tested to date (Winter 2010): 71,400
- Buds tested so far this year: 38,143

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Cool Climate Oenology & Viticulture Institute
Brock University

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WIN Weather INnovations Incorporated

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Thank you for your attention.

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