Varietal Differences in Grapevine Hardiness
Buds, Canes and Roots

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Examples of Grapevine Winter Injury

Vine collapse - 3 year old Shiraz
August 25, 2015

Stunted/delayed shoot growth - Merlot
May 24, 2018

In both cases there is no bud damage from cold temperature, yet the vine's vascular system has been severely compromised in the previous winter.

Varietal Bud Hardiness of Wine Grapes in the Okanagan Valley

2013 - 2014 Winte			
Location	Variety	Avg LTE*/site (Oct 25)	Avg LTE/site (Nov 8)
Black Sage	Cabernet Franc	-12.9	-17.7
Oliver, east	Cabernet Franc	-13.1	-18.2
Osoyoos, northeast	Cabernet Sauvignon	-12.9	-17.0
Osoyoos, northeast	Cabernet Sauvignon	-11.9	-15.8
Osoyoos, southeast	Cabernet Sauvignon	-11.8	-17.9
Black Sage	Cabernet Sauvignon	-11.3	-17.5
Osoyoos, southeast	Chardonnay	-14.2	-20.7
Black Sage	Chardonnay	-13.1	-19.1
Naramata Bench	Chardonnay	-13.6	-18.9
OK Falls, east	Chardonnay	-14.2	-19.4
Oliver, east	Chardonnay	-14.4	-19.0
OK Falls, west	Gewurztraminer	-13.0	-19.2
Oliver, east	Gewurztraminer	-13.2	-19.9
Oliver, west	Merlot	-11.1	-13.8
Osoyoos, northeast	Merlot	-12.6	-17.9
Black Sage	Merlot	-12.5	-19.5
Black Sage	Pinot blanc	-13.6	-19.3
Oliver, east	Pinot blanc	-14.2	-20.7
Black Sage	Pinot gris	-15.1	-20.0
Oliver, east	Pinot gris	-16.0	-21.7
Naramata Bench	Pinot gris	-12.2	-16.3
OK Falls, east	Pinot gris	-16.4	-20.1
Oliver, east	Pinot gris	-13.9	-19.5
Black Sage	Pinot noir	-14.6	-19.3
Kelowna	Pinot noir	-14.0	-20.0
Osoyoos, northeast	Pinot noir	-14.6	-20.6

2012 – 2013
11 varieties - 36 sites

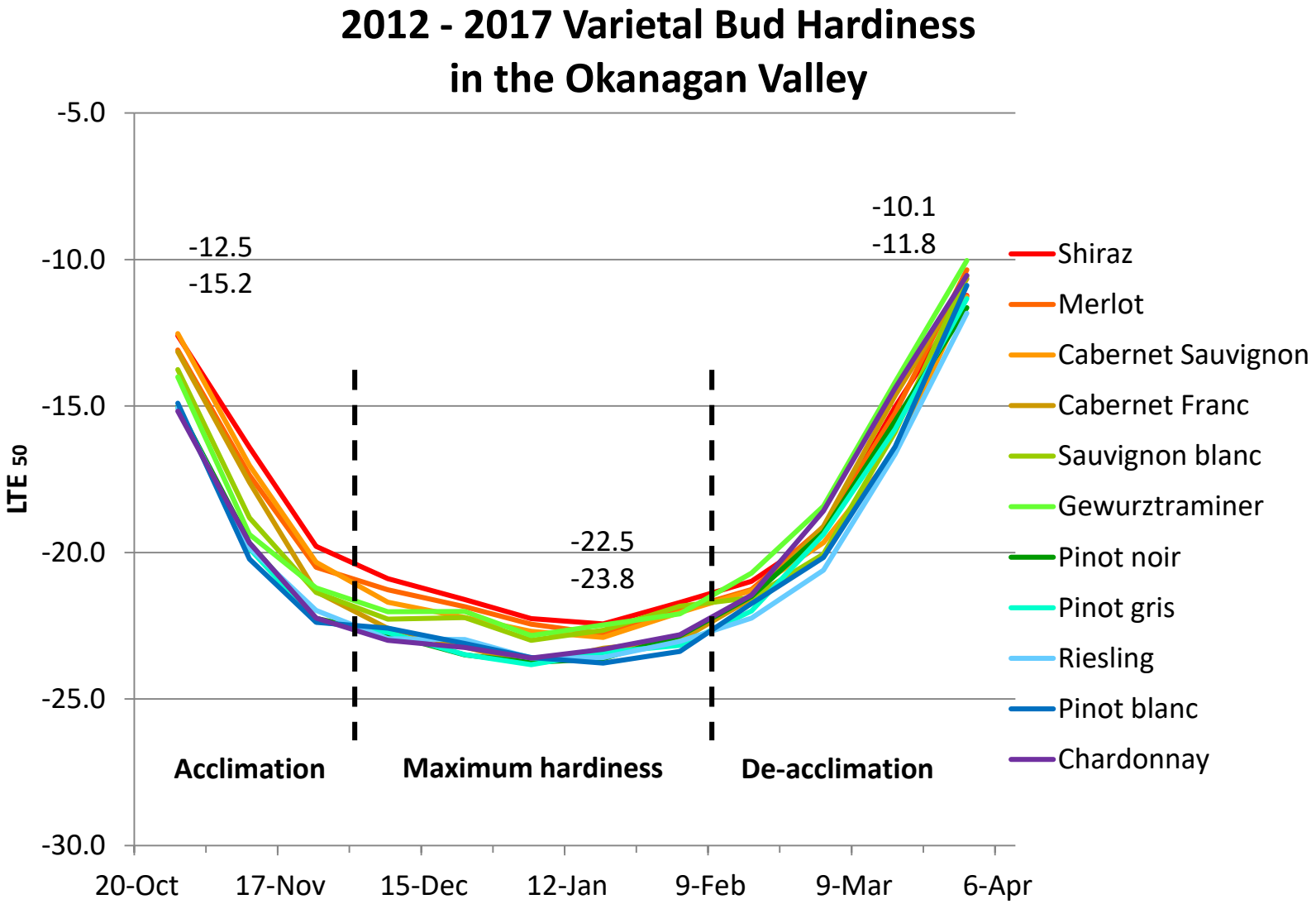
Now
15 varieties - 71 sites

Sampling Protocol:

- Select sites and vines to be sampled (6 vines/site)
- Every 2 weeks from Nov 1 to Apr 1 sample 3 canes/site
- Determine hardiness (DTA) on 5 buds/cane (buds 3 - 7)
- Post bud hardiness to growers within 2 days of sampling

Bud hardiness (LTE_{50}) = mean bud mortality temperature of 15 buds from 3 canes per site.

Grapevine Varieties Differ in Winter Hardiness



Varietal Bud Hardiness for Vitis vinifera in the Okanagan Valley
(2012 - 2017)

Acclimation (Oct - Nov)			Max hardiness (Dec - Feb)			Deacclimation (Mar - Apr)		
variety	hardiness*	duncan[x]	variety	hardiness	duncan	variety	hardiness	duncan
Shiraz	1.72	A	Shiraz	0.82	A	Gewurzt	0.94	A
Cab Sauv	1.34	AB	Gewurzt	0.70	AB	Chard	0.74	AB
Merlot	1.10	B	Merlot	0.64	AB	Cab Franc	0.52	ABC
Cab Franc	0.48	C	Cab Sauv	0.42	AB	Merlot	0.46	ABC
Gewurzt	-0.06	C	Sauv blanc	0.32	B	Shiraz	0.18	BCD
Sauv blanc	-0.08	C	Chard	-0.32	C	Pinot noir	-0.04	CDE
Pinot noir	-0.72	D	Pinot blanc	-0.44	C	Pinot gris	-0.28	DE
Riesling	-0.84	D	Cab Franc	-0.46	C	Sauv blanc	-0.38	DE
Chard	-0.90	D	Pinot noir	-0.52	C	Cab Sauv	-0.40	DE
Pinot gris	-0.94	D	Riesling	-0.56	C	Pinot blanc	-0.64	EF
Pinot blanc	-1.08	D	Pinot gris	-0.62	C	Riesling	-1.08	F

Bud Hardiness

least

most

# of samples	3	5 or 6	2 or 3
Temp range	2.8˚C	1.4˚C	2.0˚C

* Relative bud hardiness (˚C) Note: positive values are less hardy than negative values.

[x] Duncan's multiple range test - Means followed by the same letter and not significantly different

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WSU Grapevine Cold Hardiness - Research and Extension

Date	Variety	BUD10 °F	BUD50 °F	BUD90 °F	PHL10 °F	XYL10 °F
1/13/2014	Merlot	-6.5	-9.5	-10	1	-4.5
1/13/2014	Syrah	-8	-9	-11.5	2.5	-5.5
1/13/2014	Chardonnay	-10	-12	-13	0.5	-8.5
1/13/2014	Cabernet Sauvignon	-8.5	-10.5	-12.5	1	-14
1/7/2014	Malbec	-10	-12	-13.5	1.5	-5.5
1/3/2014	Sangiovese	-4.5	-7.5	-10	6.	
1/3/2014	Barbera	-9.5	-11.5	-130	2.	
1/3/2014	Nebbiolo	-9	-12	-14		
1/9/2014	Zinfandel	-8.5	-10.5	-13		
1/9/2014	Petit Verdot	-10.5	-11.5	-13.5	1	-7
1/9/2014	Lemberger	-6	-8.5	-11.5	1.5	-8.5
1/9/2014	Grenache	-5	-8	-9.5	3.5	-3.5
1/3/2014	Pinot noir	-10	-12.5	-14	1.5	-9.5
1/2/2014	Gewurztraminer	-7	-10.5	-13	1	-16
1/2/2014	Auxerrois	-9	-12	-13	1.5	-7.5
1/2/2014	Sauvignon blanc	-5	-9	-10.5	7.5	-7
1/2/2014	Pinot Gris	-8	-12	-13.5	0.5	-8
1/7/2014	Semillon	-5	-9.5	-12	1.5	-9
1/8/2014	Muscat blanc	-5	-9.5	-10	-0.5	-8.5
1/8/2014	Green Veltliner	-8.5	-10.5	-12	1.5	-6
1/8/2014	Chenin blanc	-8	-10	-13.5	2	-7.5
1/8/2014	Alvarinho	-11.5	-13.5	-15	1.5	-8.5
1/7/2014	Riesling	-11	-12.5	-14.5	-3.5	-18.5
1/7/2014	Concord	-17	-19	-20	-8.5	-21.5

Last updated by Lynn Mills on Jan 14, 2014 at 10:11 AM

← °C = (°F – 32) x 5/9

Google
WSU grape cold hardiness

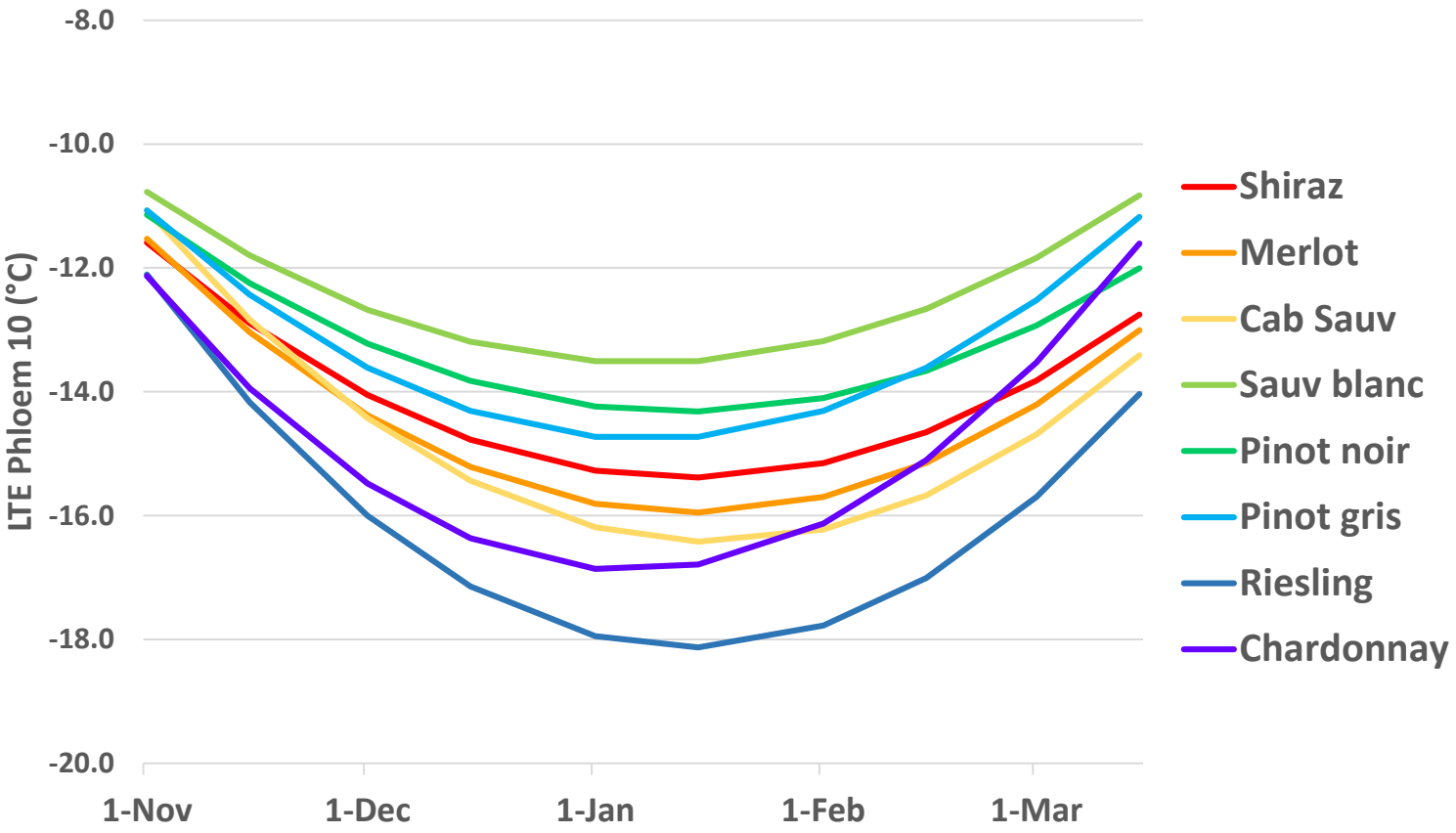
On average:

- Phloem is 5.6°C less hardy than buds (PHL10 – BUD10)
- Xylem is just as hardy or hardier than buds

http://wine.wsu.edu/extension/weather/cold-hardiness/

Grapevine Varieties Differ in Phloem Winter Hardiness

2013 – 2018 Varietal Phloem Hardiness*



* Plotted are 2nd order polynomial equations of WSU Phl10 data 2013-2018

Grapevine Varieties Differ in Phloem Winter Hardiness

Phloem Hardiness Relative to Bud Hardiness (Bud50 – Phl10)

(Dec 15 - Feb 15)				
variety	hardiness difference (°C)	Duncan*	rank Bud50	rank Phl10
Riesling	5.6	A	7	8
Chardonnay	6.5	AB	5	7
Cab Sauv	6.8	ABC	3	6
Merlot	6.9	ABC	2	5
Shiraz	8.0	BCD	1	4
Pinot noir	8.1	BCD	6	2
Pinot gris	8.5	CD	8	3
Sauv blanc	8.7	D	4	1

*** Duncan multiple range test – means with the same letter are not significantly different.**

- Phloem appears to be much less tolerant of cold temperatures than buds.
- Varietal ranking of buds and phloem hardiness are dissimilar, indicating phloem hardiness is unrelated to bud hardiness.
- For overall cold tolerance Sauvignon blanc maybe just as vulnerable to cold temperatures as Shiraz.

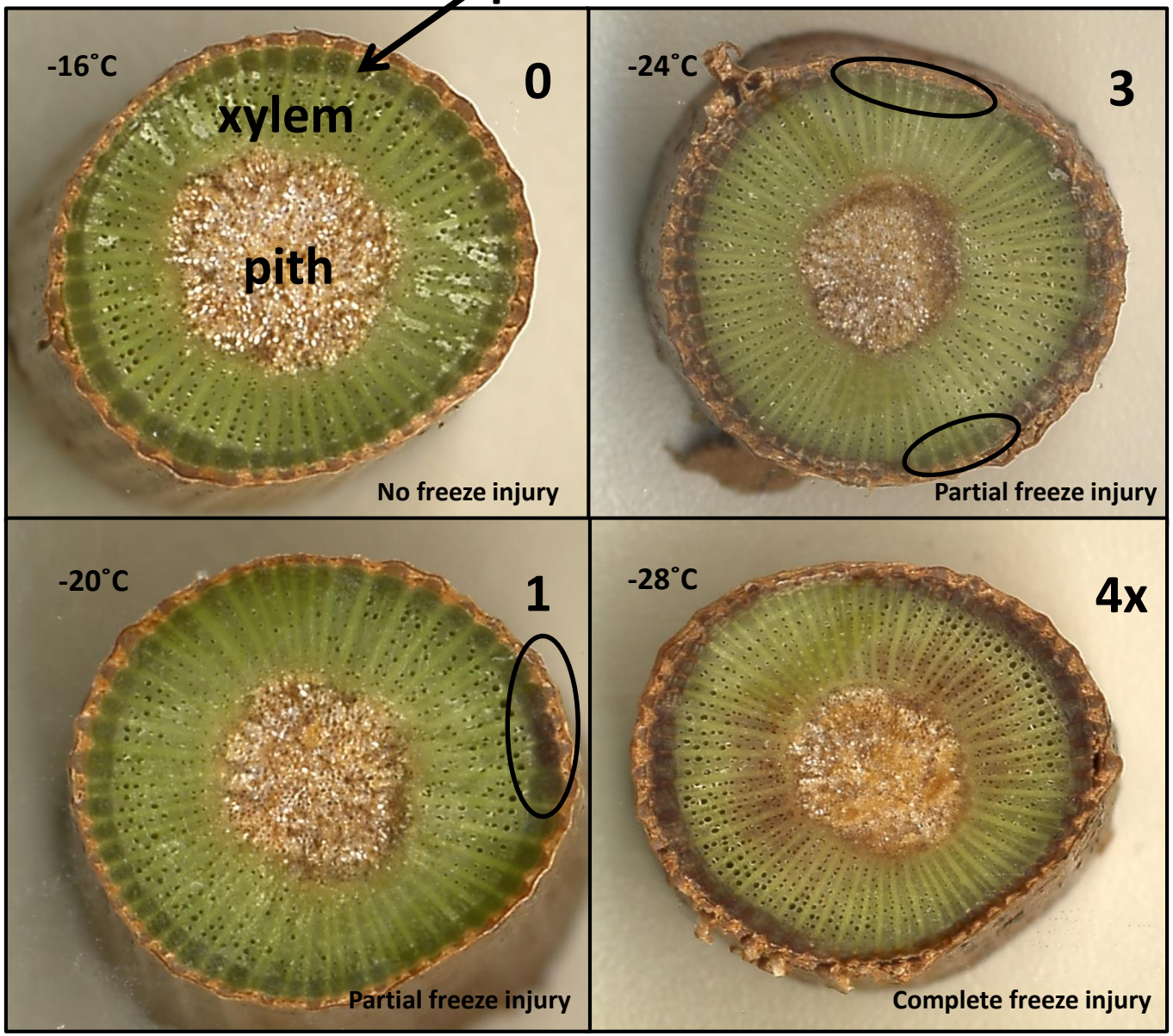
Cross-Sections of Merlot Canes Exposed to Falling Temperatures

Images recorded
January 11, 2016
(6 days post freezer trt)

Bud LTE_{50} = -23.7

Phloem Damage Rating

0 = 0%
1 = 1 - 10%
2 = 10 - 80%
3 = 80 - 95%
4 = 95 - 100%
(- xylem damage)
4x = 95 - 100%
(+ xylem damage)



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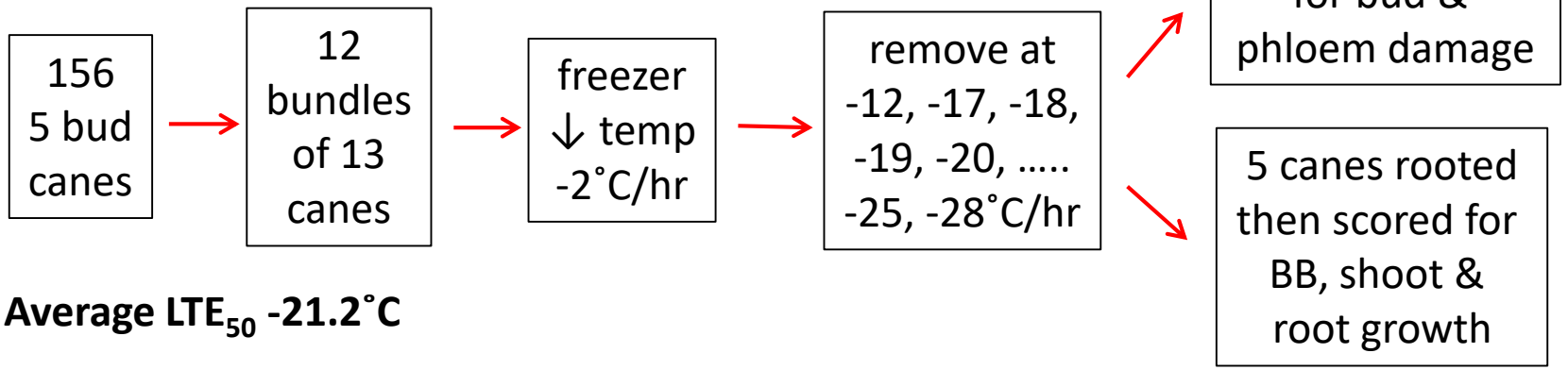
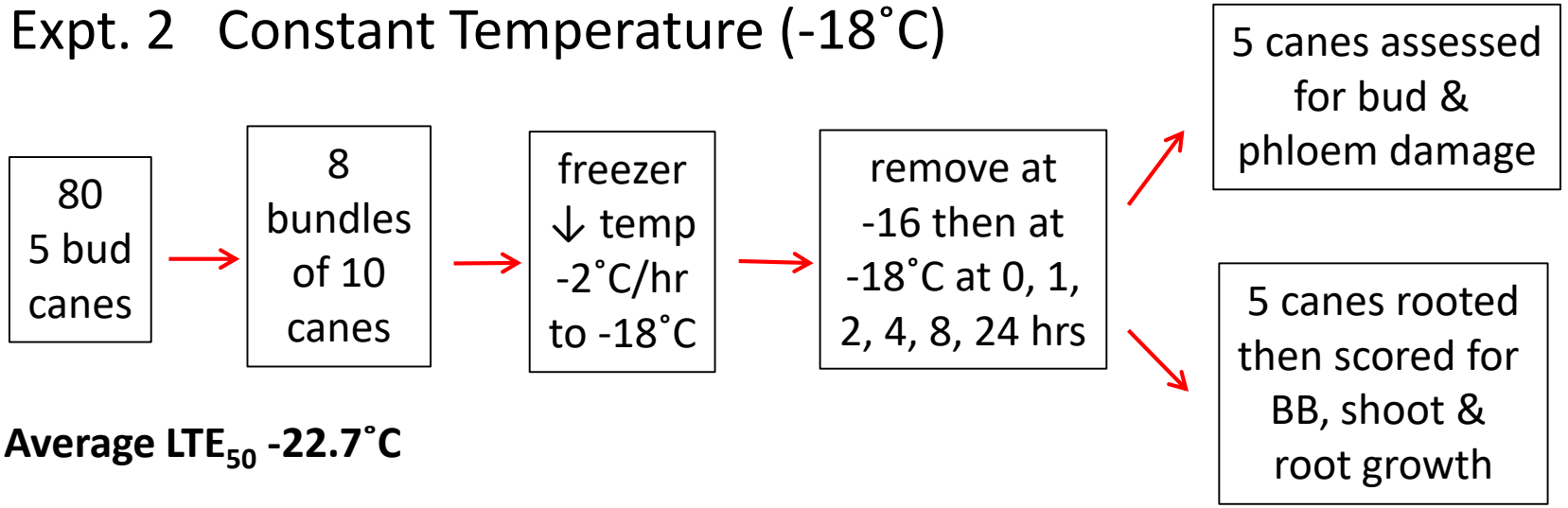
Assessing Cold Temperature Injury to Phloem Tissue

Expt. 1 Steadily Decreasing Temperatures



Average LTE_{50} -21.2˚C

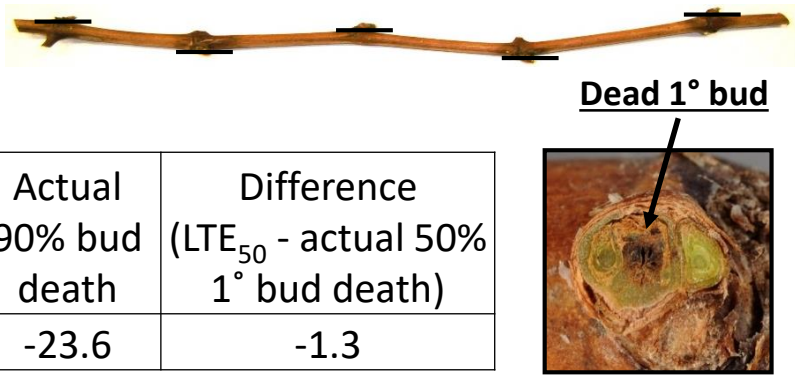
Expt. 2 Constant Temperature (-18˚C)



Average LTE_{50} -22.7˚C

Results - Expt. 1 Steadily Decreasing Temperatures

Comparison of 1° bud mortality as determined by standard DTA (LTE_{50}) versus that by visual inspection (actual bud mortality).



Measured & Actual Bud Mortality	LTE_{50} Differential Thermal Analysis	Actual 10% bud death	Actual 50% bud death	Actual 90% bud death	Difference (LTE_{50} - actual 50% 1˚ bud death)
average (˚C)	-21.2	-20.4	-22.5	-23.6	-1.3

Average of 7 test runs

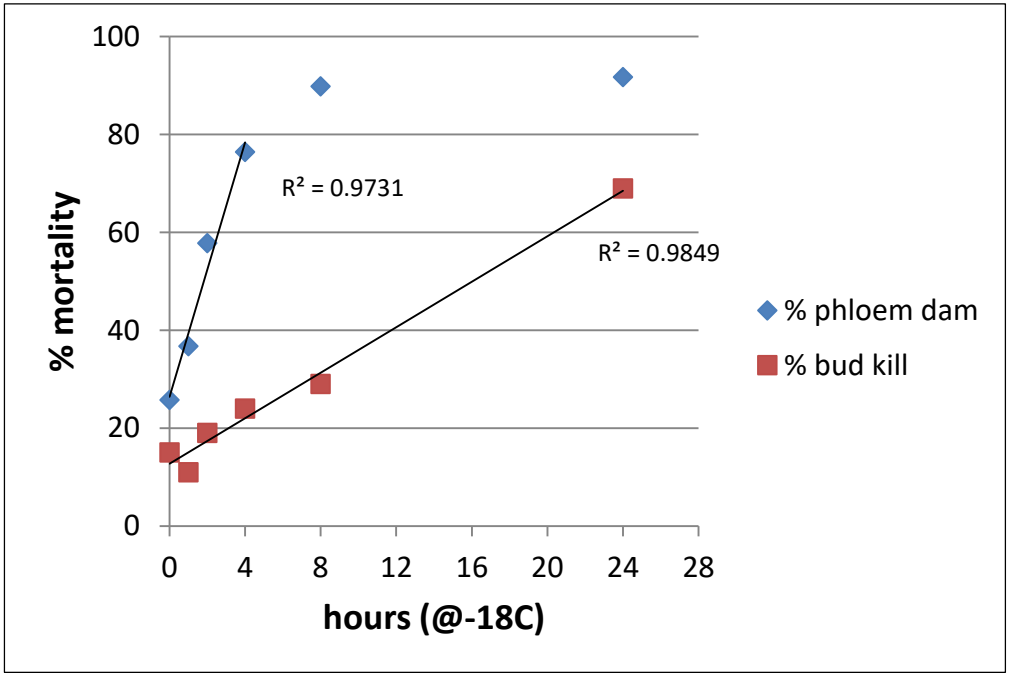
Relationship of phloem injury with % reduction in normal shoot and root growth for canes rooted in water. (average Bud LTE_{50} -22.3)

Rating	Range in phloem damage (%)	Equivlent to: (WSU extension)	Average T exposure (˚C)	% bud break	% 1˚ bud mortality	% clusters/ shoot	% total shoot length	% total root length
1	1 - 10	phloem10	-20.6	0	10	5	2	9
2	10 - 80	phloem50	-22.2	0	34	16	25	69
3	80 - 95	phloem90	-23.5	69	47	30	59	99

Average of 5 test runs. Normal shoot and root growth was determined with canes exposed to -12˚C temperatures.

Results - Expt. 2 Constant Temperature (-18˚C)

Bud and phloem mortality for Merlot canes exposed to a constant non-lethal cold temperature



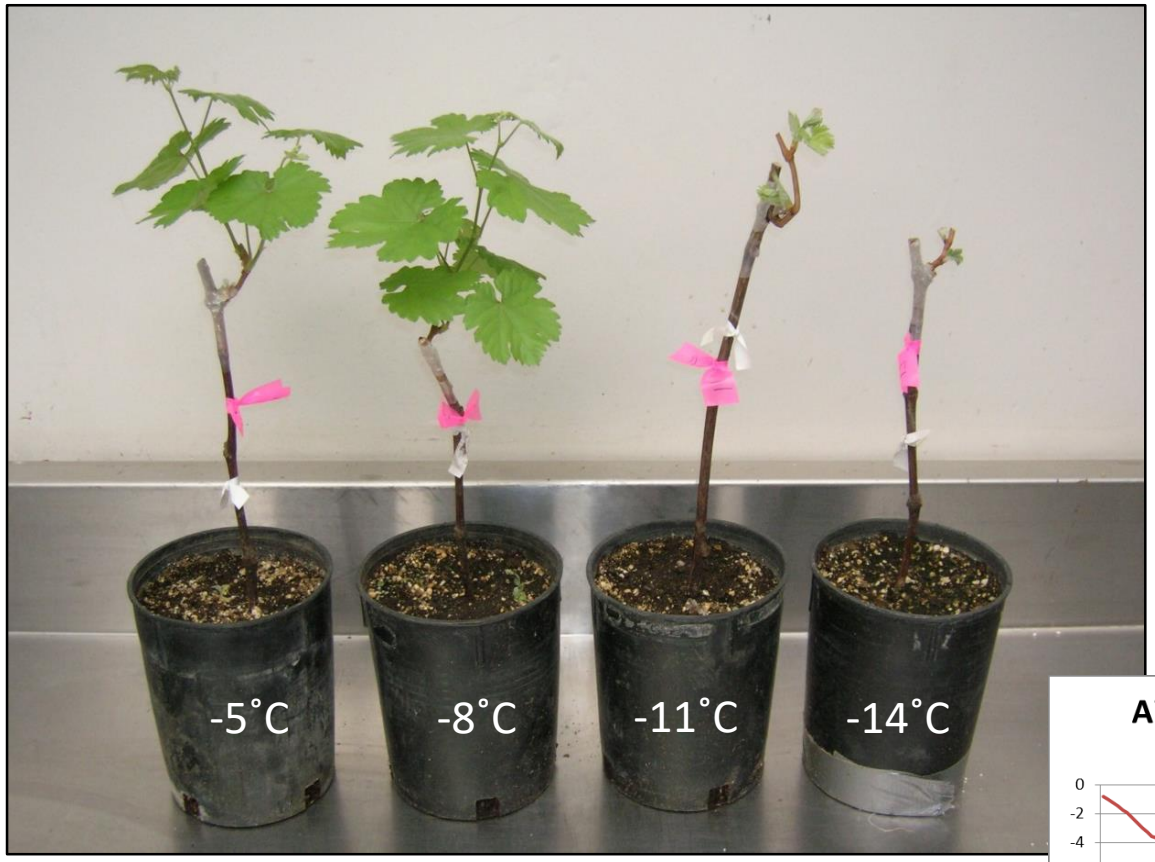
Merlot canes at 6 weeks post freezer treatment

Average of 4 test runs

Average LTE_{50} -22.7°C.

- Initial bud & phloem damage prior to sampling canes averaged 5% & 13%, respectively.
- At -18°C for 8 hours, bud damage averaged 29% & phloem damage averaged 90%.
- The duration of constant non-lethal cold temperatures has a greater effect on phloem tissue than on buds.

Cold Temperature Injury to Roots



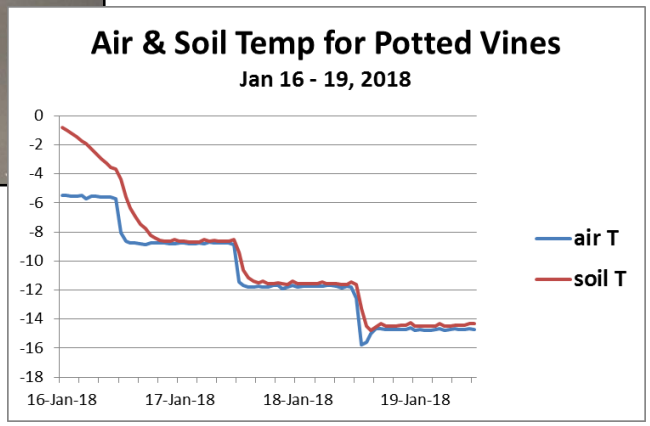
Merlot/3309C

Dormant vines stored at 2°C are exposed to sub-zero temperatures for 24 hours

-5˚C and -8˚C normal shoot & root growth

-11˚C delayed bud break, slowed shoot growth, old roots mostly killed with new roots originating from wood

-14˚C delayed bud break, almost no shoot growth, old roots killed & no new root growth



Root Hardiness for Merlot & 8 Merlot/Rootstock Combinations

- March 16 – 19, 2018, made bench grafts with rootstock cuttings & Merlot
- July 16, 2018 planted vines in a single row nursery, spaced 27cm apart
- Treatments were replicated in 4 blocks with 6 subsample vines per plot
- Single vines were dug up for hardiness testing Nov 13, Nov 27, Dec 12 …

VARIETY	VIGOR +	PHYLOXERA RESISTANCE	NEMATODES RESISTANCE	SOIL PREFERENCE	DROUGHT TOLERANCE	INFLUENCE ON MATURITY	ROOT HARDINESS	LTE IR ROOT90 Dec 12
Merlot	H	L	L	LOAM	M	M	VL	Least Hardy A*
110R	H	H	M	MFERT	H	L	L	A
Ramsey (Salt Crk)	H	M	H	SAND	H	L	M	B
SO4	M	H	MH	CLAY	L	M	M	B
5C	M	H	H	CLAY	L	E	M	B
Riparia Gloire	LM	H	M	DEEP	L	E	MH	C
Schwarzmann	LM	H	MH	DEEP	LM		MH	C
3309C	MH	H	L	DEEP	L	M	MH	C
101-14	LM	H	M	CLAY	LM	E	H	Most Hardy D

* Duncan multiple range test – means with the same letter are not significantly different.

+ Vintage Nurseries

1. Roots of *Vitis vinifera* cv Merlot are less hardy than rootstock roots.
2. Of the rootstocks roots, 101-14 was the hardiest & 110R was the least hardy.
3. Root hardiness of rootstocks appears to correlate with rootstock vigor effect.

Effect of Rootstock on Merlot Scion Bud Hardiness

- Same vines as previously described (Merlot scion buds tested)
- Single vines dug up for hardiness testing Nov 13, Nov 27, Dec 12 …

November 13, 2018			November 27, 2018			December 12, 2018		
Rootstock	LTE50	Duncan*	Rootstock	LTE50	Duncan	Rootstock	LTE50	Duncan
Merlot	Least Hardy	A	Merlot	Least Hardy	A	Merlot	Least Hardy	A
110R		AB	110R		AB	SO4		A
Ramsey (Salt Crk)		AB	101-14		ABC	101-14		A
3309C		AB	SO4		ABCD	110R		A
SO4		BC	5C		BCD	Ramsey (Salt Crk)		A
Schwarzmann		CD	3309C		BCD	3309C		A
101-14		CD	Schwarzmann		BCD	5C		A
5C		DE	Ramsey (Salt Crk)		CD	Riparia Gloire		A
Riparia Gloire	Most Hardy	E	Riparia Gloire	Most Hardy	D	Schwarzmann	Most Hardy	A
avg LTE50	-19.9		avg LTE50	-21.8		avg LTE50	-23.7	

* Duncan multiple range test – means with the same letter are not significantly different.

1. Rootstocks appear to initiate & improve scion bud hardiness during the acclimation period of winter dormancy
2. Scion buds reach maximum hardiness sooner when grafted to most rootstocks
3. There was no difference in bud hardiness between rooted Merlot and Merlot/110R
4. Merlot bud hardiness was most improved when grafted on Riparia Gloire

Winter Bud Hardiness in the Merlot Rootstock Trial

Rootstock*	LTE_{50} 18-Nov-13		LTE_{50} 20-Jan-14		LTE_{50} 10-Mar-14		LTE_{50} 17-Nov-14		LTE_{50} 19-Jan-15		LTE_{50} 16-Mar-15	
Merlot-own roots	-14.02	A	-19.47	A	all dead		-17.68	A	-20.49	A	-11.08	A
Ramsey	-15.66	AB	-22.84	B	-20.25		-19.48	AB	-22.05	AB	-12.97	AB
3309	-15.86	AB	-20.38	AB	-19.25		-20.66	B	-21.10	AB	-10.32	A
110R	-16.23	AB	-21.05	AB	-20.40		-18.34	AB	-22.49	AB	-12.21	A
Schwarzmann	-17.00	BC	-19.97	A	-19.28		-19.90	AB	-21.34	AB	-15.70	B
5C	-17.46	BC	-21.61	AB	-19.47		-20.18	AB	-23.04	B	-12.76	AB
101-14	-18.11	BC	-21.28	AB	-18.42		-20.17	AB	-20.70	AB	-12.91	AB
SO4	-18.22	BC	-20.84	AB	-17.99		-20.15	AB	-22.34	AB	-13.09	AB
Riparia Gloire	-19.30	C	-20.70	AB	-22.17		-19.46	AB	-22.36	AB	-11.83	A

*** Duncan multiple range test – means with the same letter are not significantly different.**

During the autumn acclimation period in November 2013 and 2014 buds on grafted Merlot were 2.7 ˚C hardier than buds on own-rooted Merlot.

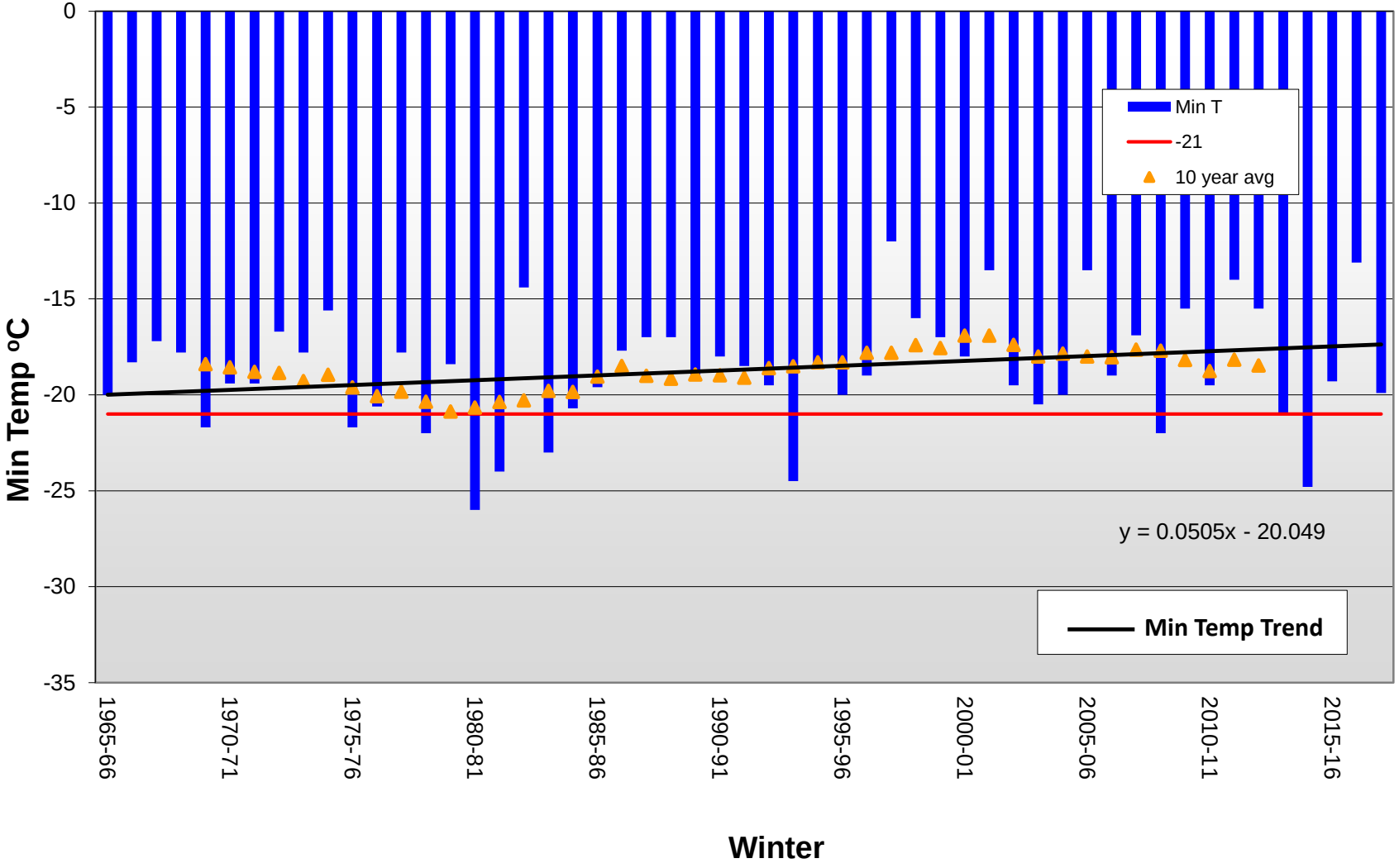
February 6, 2014 temperatures dipped to -21.5 ˚C. All buds on own rooted vines were killed.

Summary - A strategy for minimizing winter injury

Use hardier varieties and rootstocks in areas prone to colder temperatures

1. Riesling is the most cold tolerant variety of the 11 *Vitis vinefera* tested.
2. Other cold tolerant white wine grape varieties are Pinot gris and Pinot blanc.
3. Chardonnay is also very cold tolerant but breaks bud early & maybe susceptible to spring frost.
4. Pinot noir and Cabernet Franc are the most cold tolerant of the red wine grape cultivars tested.
5. Riesling and Chardonnay appear to have hardier wood than Sauvignon blanc & Pinot gris.
6. Roots of devigorating rootstocks are hardier than roots of non-devigorating rootstocks.
7. Roots of 101-14, Riparia Gloire, Scharzmann & 3309C are hardier than 110R & Ramsey.
8. Rootstocks enhance bud hardiness of young vines.

Annual Minimum Temperatures 1965 - 2018
Vineland, Ontario



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Acknowledgements:

Brad Estergaard, Steve Marsh, Emmanuelle Jean & Rob Brownlee

Mission Hill Family Estate Winery & Arterra Wines Canada

BC Wine Grape Council & AAFC DIAP & AIP Initiatives

Canadian Grapevine Certification Network & AAFC CAP Initiative