The Use of Abscisic Analogs to Mitigate the Effects of Climate Change and Red Blotch Infection

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Overview

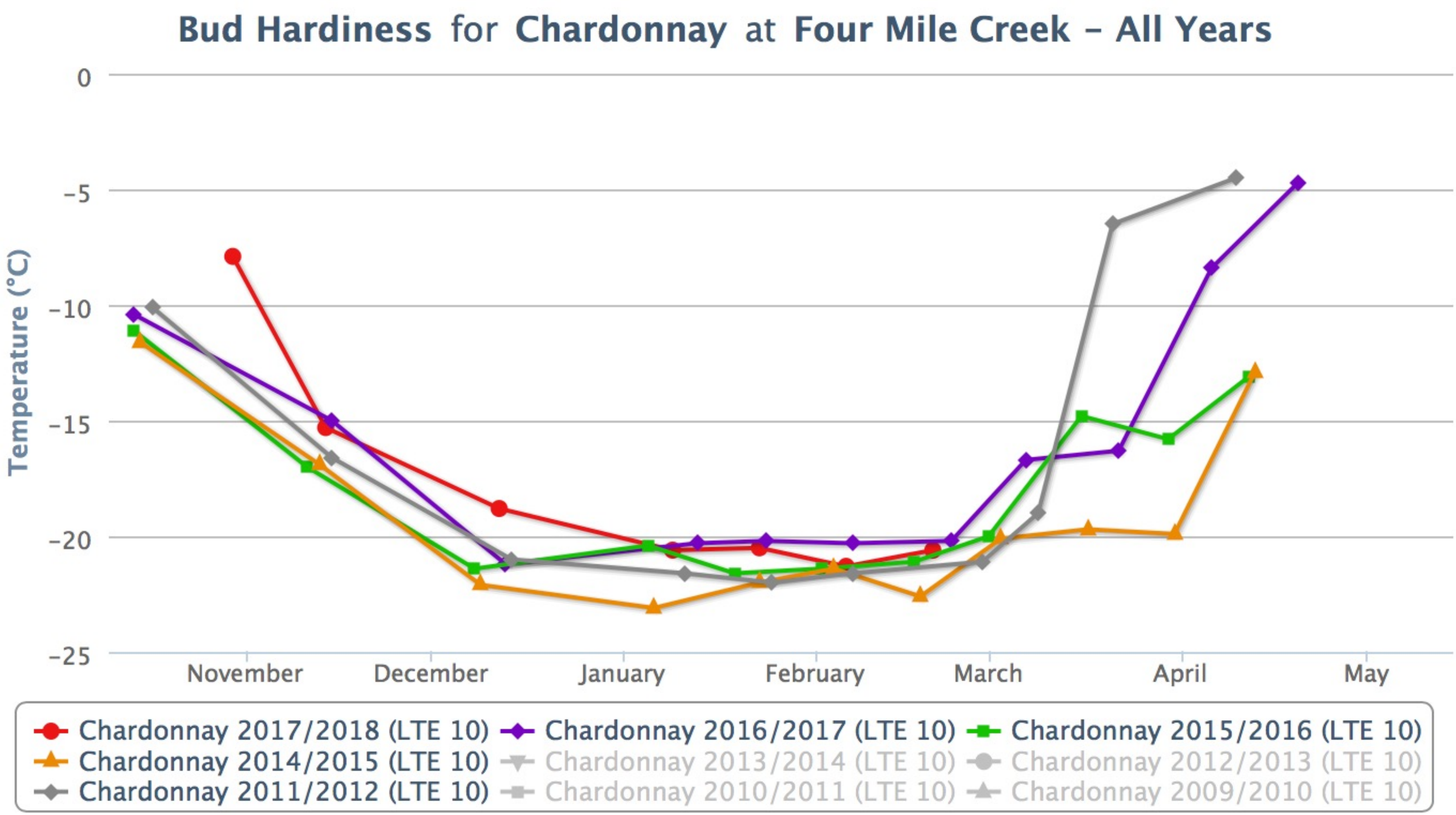
- **In the Niagara Region the cold and unpredictable weather can be problematic to grapevines causing winter damage.**
  - Typically, a warm spell will occur in the winter
  - Some years will have an early or late frost event potentially damaging the vine.
- **With increasing presence of viruses in vineyards, management strategies to mitigate the effects of viruses are important**

Climate change and cold hardiness

- **Studies indicate a:**
  - Rise of the average temperature
  - More heat waves and days with >30°C
  - Higher drought incidence
  - Reduced snow cover and increased rainfall in winter
  - More extremes weather events

  - We farm extremes and weather has a significant impact on production

Impacts of warm weather on deacclimation



Potential solution to addressing climate change impacts

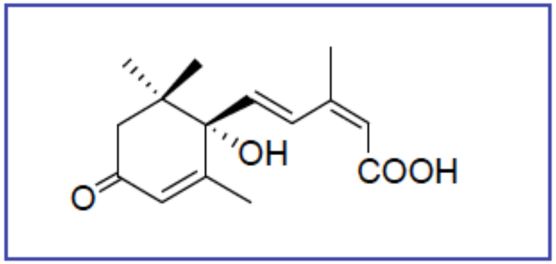
- **Plant growth regulators (PGRs) can be a powerful tool**
- **Commonly used already in hot climate regions**
  - Widely used for Table grape production
  - Tropical viticulture
- **Various PGRs are used depending on the production or quality issue**
- **Very limited use in Canada**

Use of PGRs in grape cultivation

PGR	Purpose of Use	Stage
Gibberlins (GA)	Cluster Elongation Berry thinning Berry sizing	Pre-bloom Bloom After fruit set
Cytokinins	Berry sizing	After fruit set
Abscisic Acid (ABA)	Berry coloration	Veraison
Ethylene	Berry coloration	Veraison

Background on Abscisic Acid (ABA)

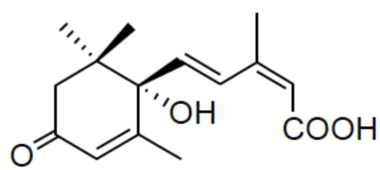
- **Isoprenoid plant hormone found in all plants**
- **Regulates a wide range of processes in plant growth and development**
  - Response to abiotic stress
    - Transpiration
    - Response to heat, drought, salinity and freezing
  - Growth and development
    - Growth inhibition
    - Abscission, senescence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



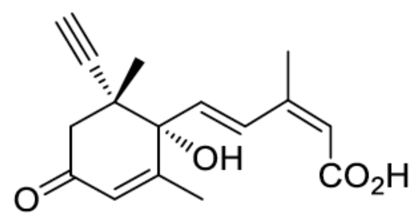
S-(+)-Abscisic acid

Abscisic Acid (ABA) analogs

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



Natural ABA

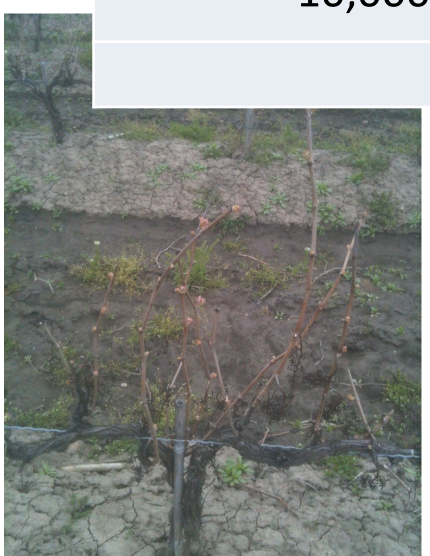


8′-Acetylene ABA

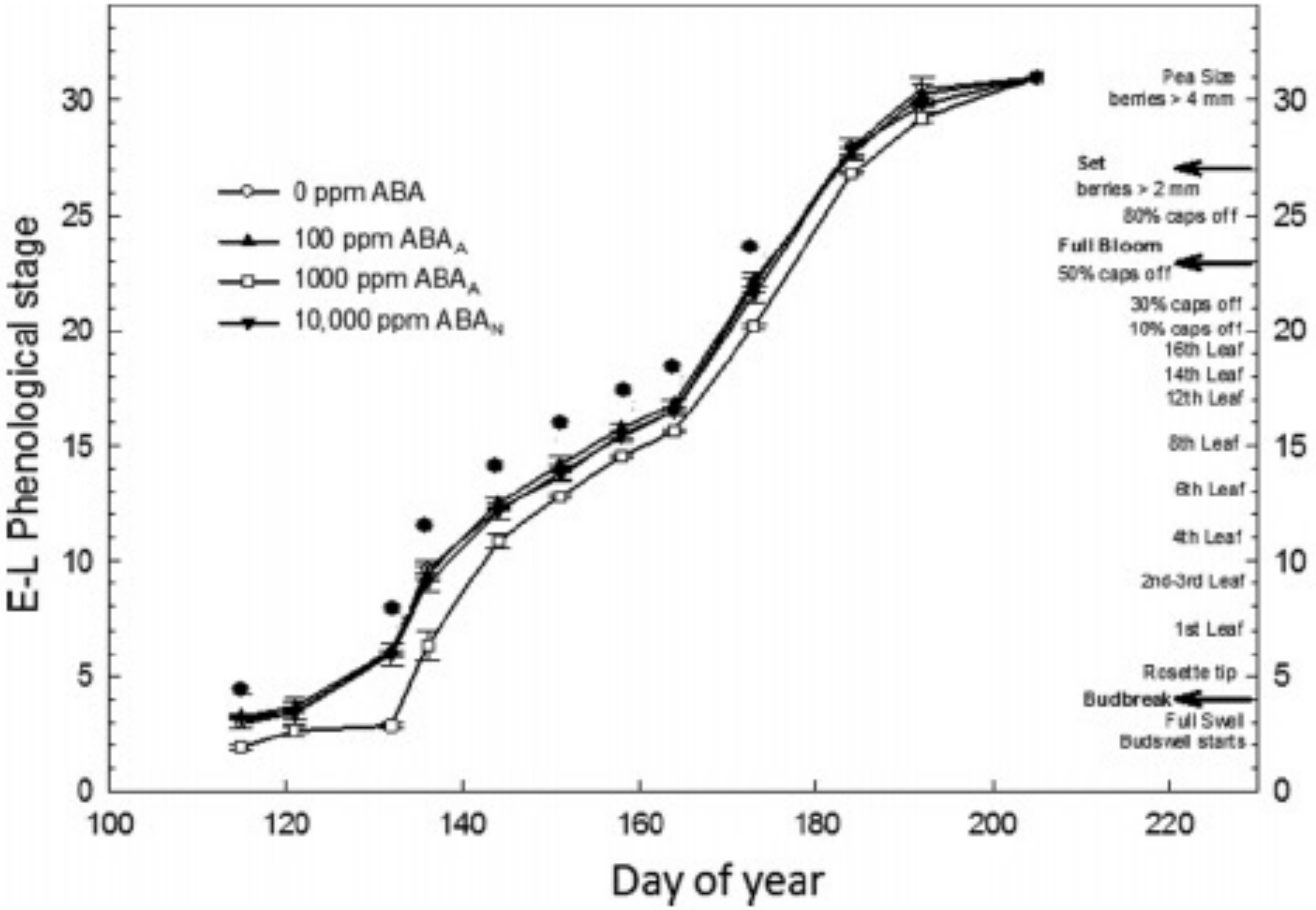
Cold Hardiness studies ABA and ABA_A field applications

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



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)

Abscisic acid analog treated vines can delay deacclimation and budbreak

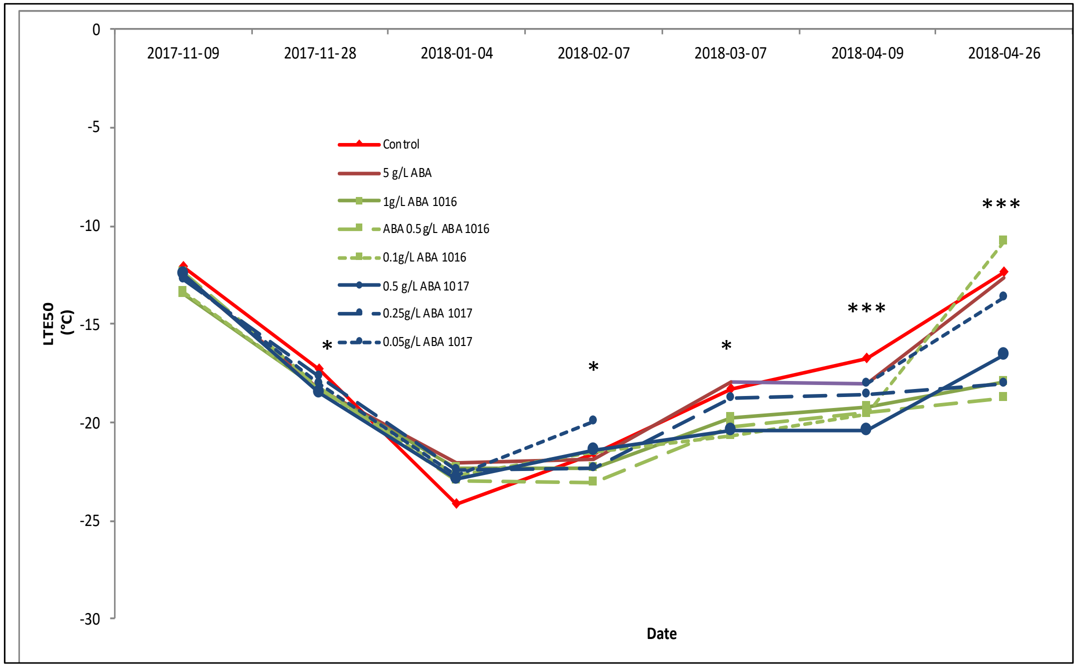


Figure 1. Cold hardiness dynamics of Merlot grapevines based on exogenous ABA_A treatments. Creek Shores, 2018. (*, ** represent statistical significance @ $p<0.05$, $p<0.001$, respectively)

Recent trials using ABA analogs (ABA_A)

- **Synthesis of long-lasting ABA analogs**
  - Abram's laboratory at Univ. of Sask.
  - 2 different compounds compared to natural ABA
- **Field trialing of post-harvest applications at different rates for cold sensitive (S. blanc, Merlot), cold hardy (Riesling) and *riparia* based hybrid (Marquette)**

The effects of ABA_A on the vine will be monitored to measure the effect of these compounds on:

  - maintaining/improving cold hardiness of grapevines that are susceptible to cold deacclimation.
- **Measure impact on dormancy, cold tolerance, bud survival, phenology particularly timing of bud break**
- **Biochemical analysis of ABA and catabolites in tissue and how it changes over dormancy**
  - Natural levels vs post-application/analog catabolites?
- **Gene expression analyses and upcoming transcriptome analyses**

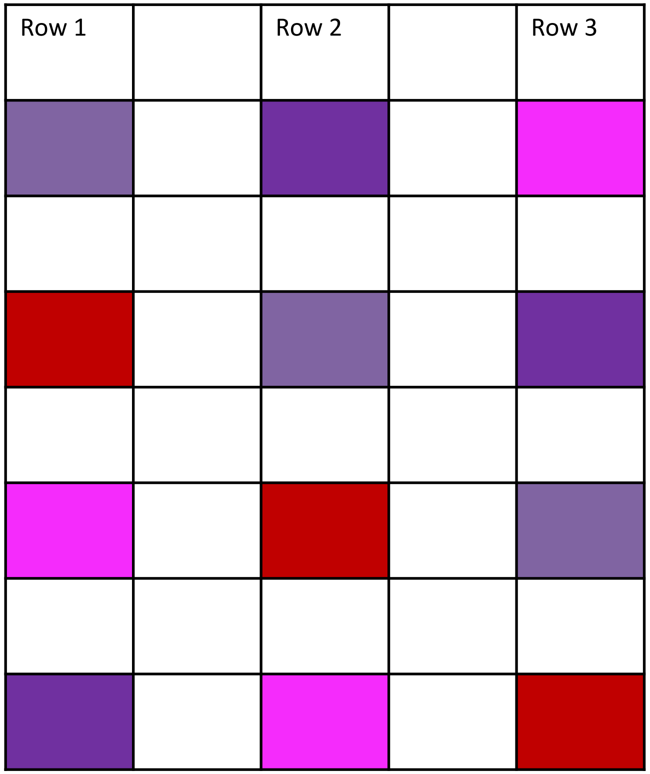
Merlot and Marquette field trials

Experimental Blocks

- Marquette - Jordan
- Merlot - West St. Catharines

- **ABA Treatments**
  - Control
  - 5 g/L Natural ABA
  - 0.5 g/L ABA 8’ Acetylene
  - 0.25 g/L ABA 8’ Acetylene

  - Applied Post harvest



Marquette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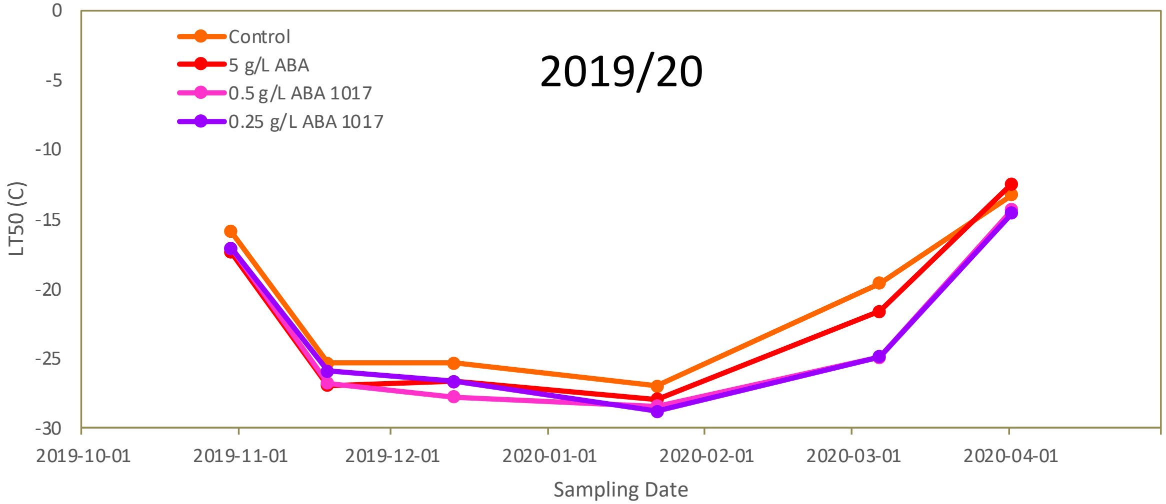
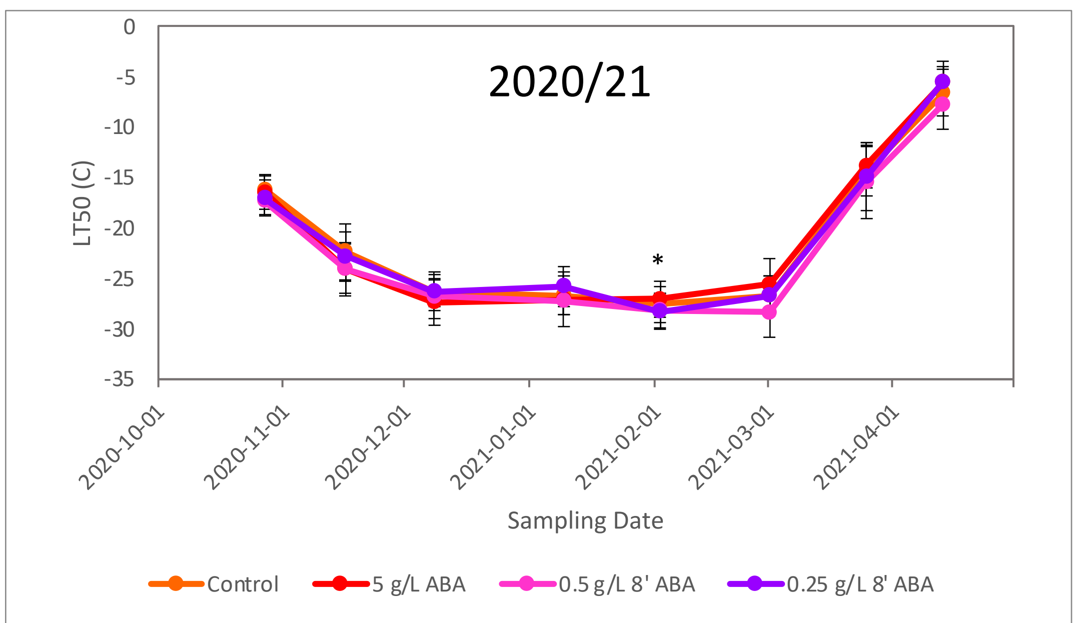
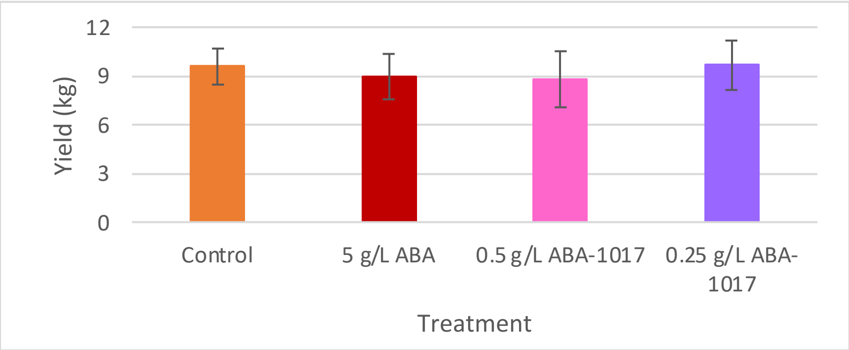
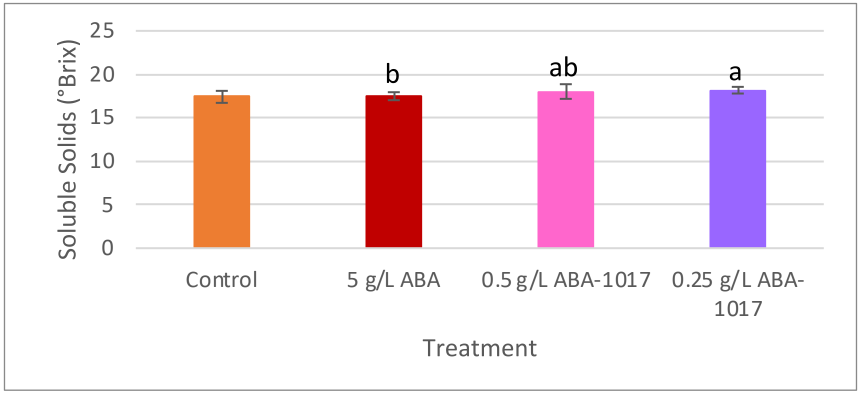
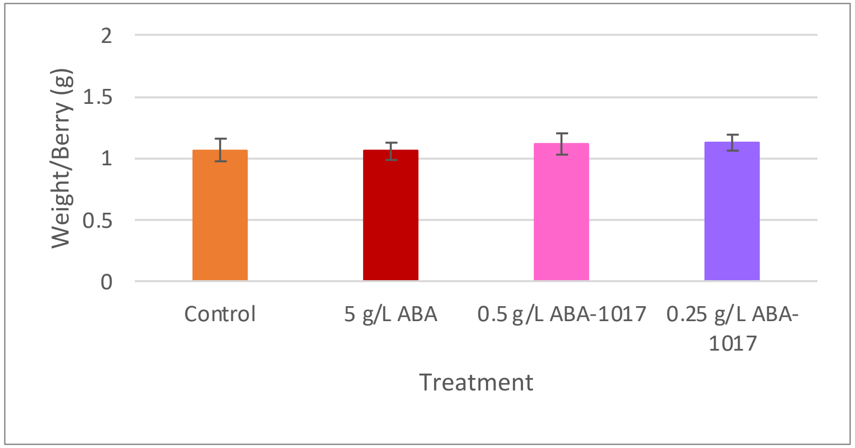

2019/20
Control
5 g/L ABA
0.5 g/L ABA 1017
0.25 g/L ABA 1017
LT50 (C)
0
-5
-10
-15
-20
-25
-30
2019-10-01
2019-11-01
2019-12-01
2020-01-01
2020-02-01
2020-03-01
2020-04-01
Sampling Date

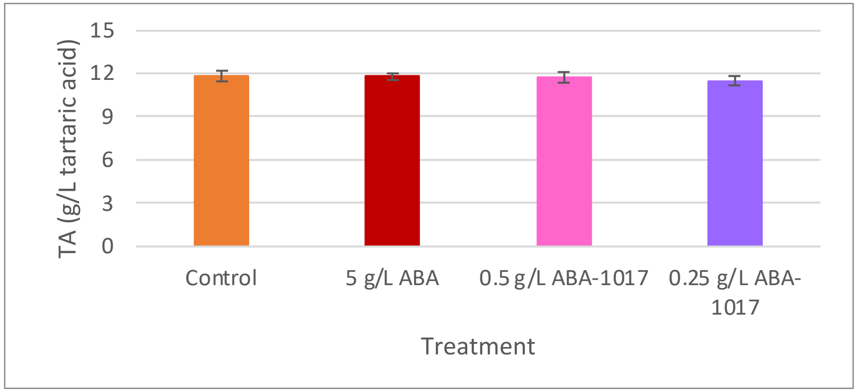

2020/21
*
LT50 (C)
0
-5
-10
-15
-20
-25
-30
-35
2020-10-01
2020-11-01
2020-12-01
2021-01-01
2021-02-01
2021-03-01
2021-04-01
Sampling Date
Control
5 g/L ABA
0.5 g/L 8' ABA
0.25 g/L 8' ABA

Marquette
Yield components and primary fruit chemistry









Merlot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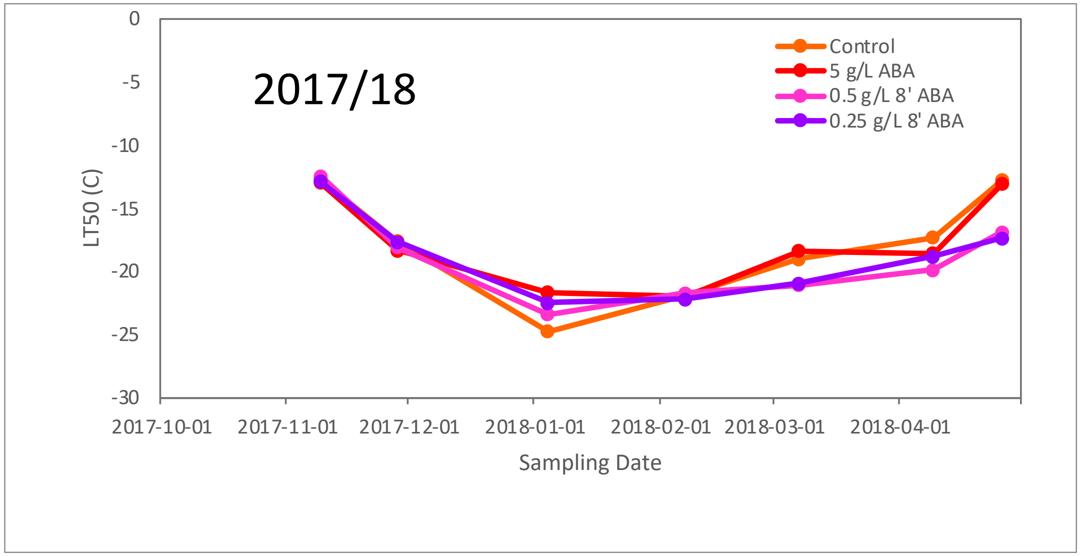
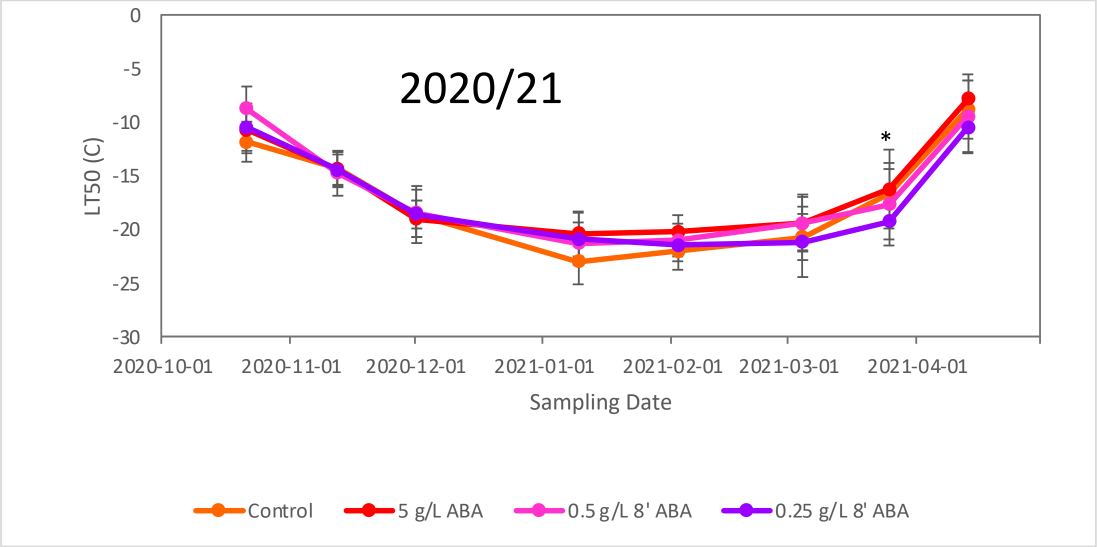
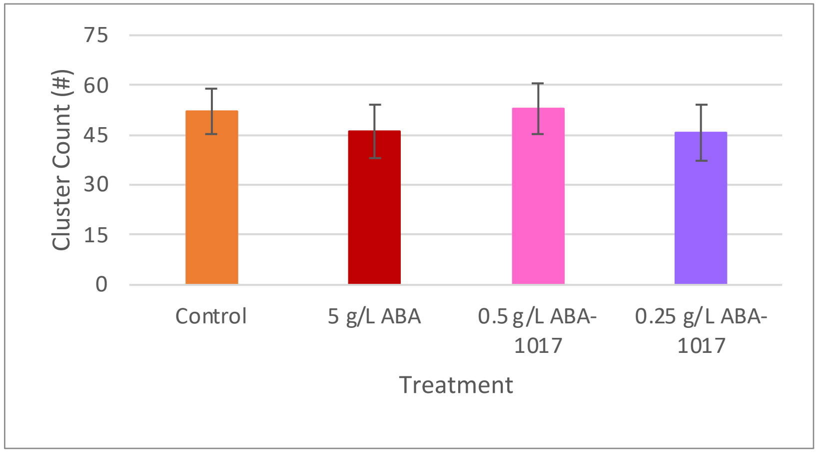
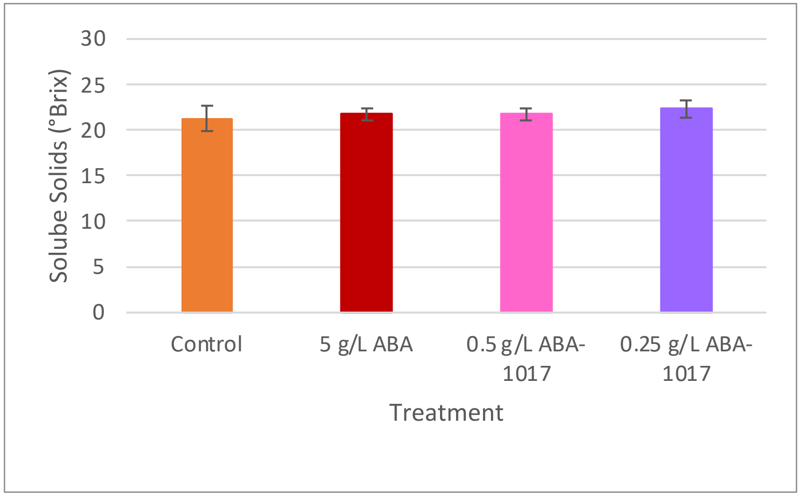
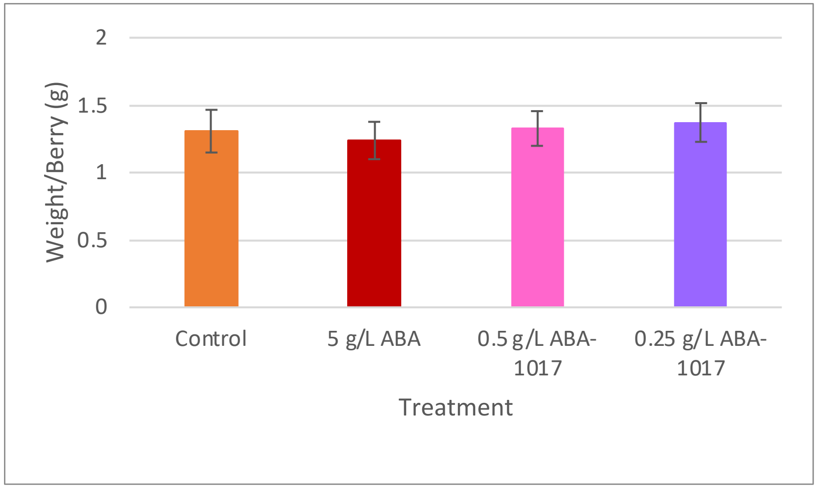

2017/18
LT50 (C)
0
-5
-10
-15
-20
-25
-30
2017-10-01
2017-11-01
2017-12-01
2018-01-01
2018-02-01
2018-03-01
2018-04-01
Sampling Date
Control
5 g/L ABA
0.5 g/L 8' ABA
0.25 g/L 8' ABA

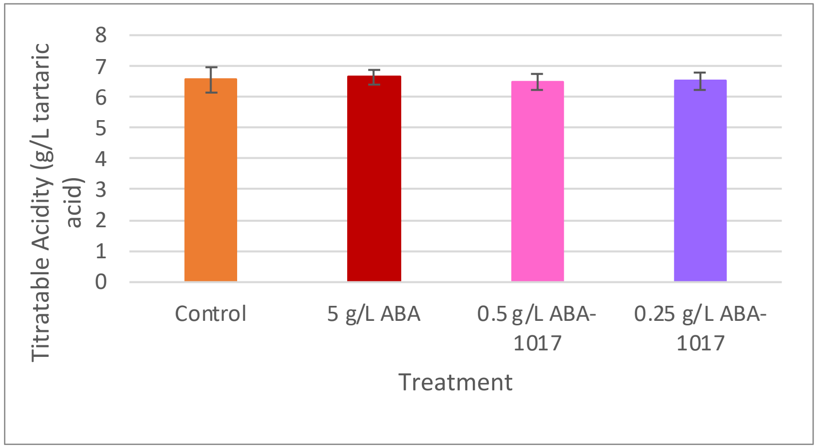

2020/21
LT50 (C)
0
-5
-10
-15
-20
-25
-30
*
2020-10-01
2020-11-01
2020-12-01
2021-01-01
2021-02-01
2021-03-01
2021-04-01
Sampling Date
Control
5 g/L ABA
0.5 g/L 8' ABA
0.25 g/L 8' ABA

Merlot
Yield components and primary fruit chemistry









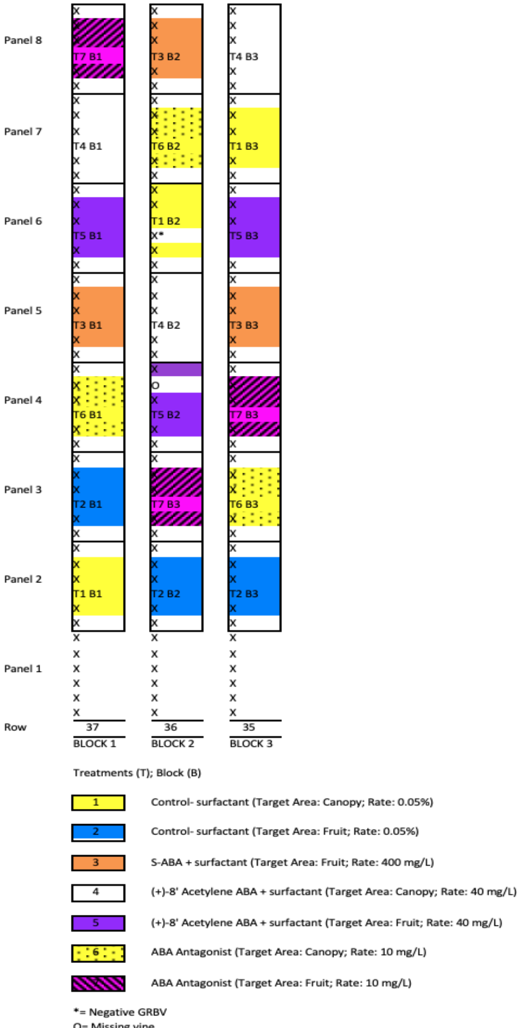
Mitigating Red Blotch virus with ABA and/or ABA_A

- Red Blotch virus leads to major economic losses
  - Mainly fruit composition related (lower sugar, higher acid, poor colour, poor flavour)
- The virus effects the biochemical pathways of the vine responsible for berry ripening
- Disrupts hormonal pathways including ABA-related pathways
- Could applications of ABA or the long-lasting ABA Analog help to mitigate these effects of the virus?
- Tested an ABA Agonist (8’-acetylene ABA) and an ABA Antagonist
- Targeted both fruit and canopy for applications as separate treatments and trialed different doses

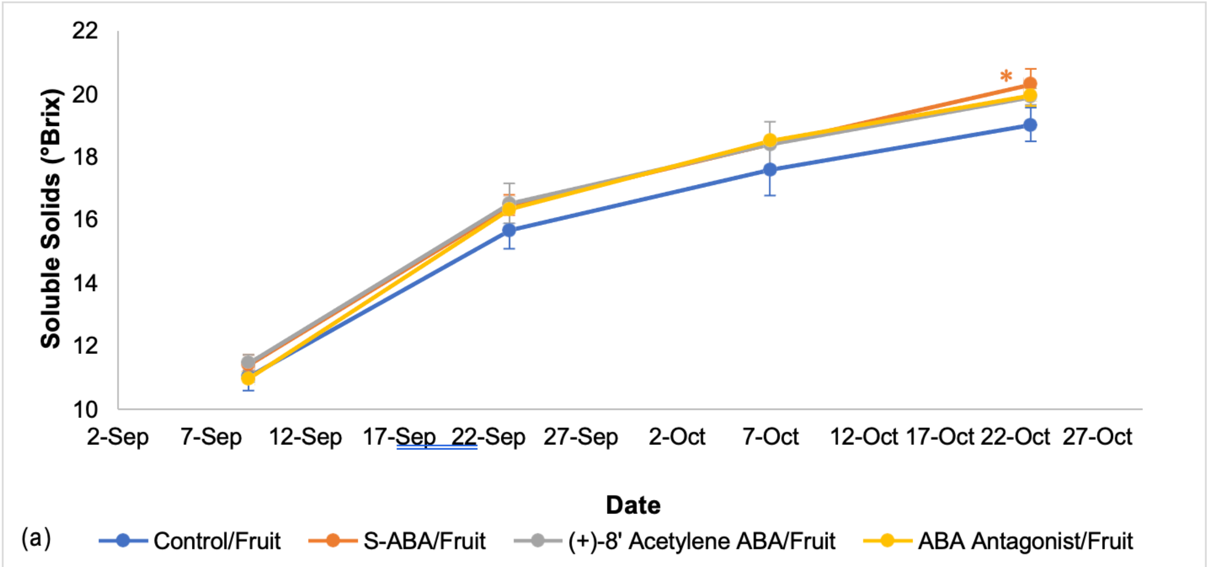
Cabernet Franc ABA Treatments

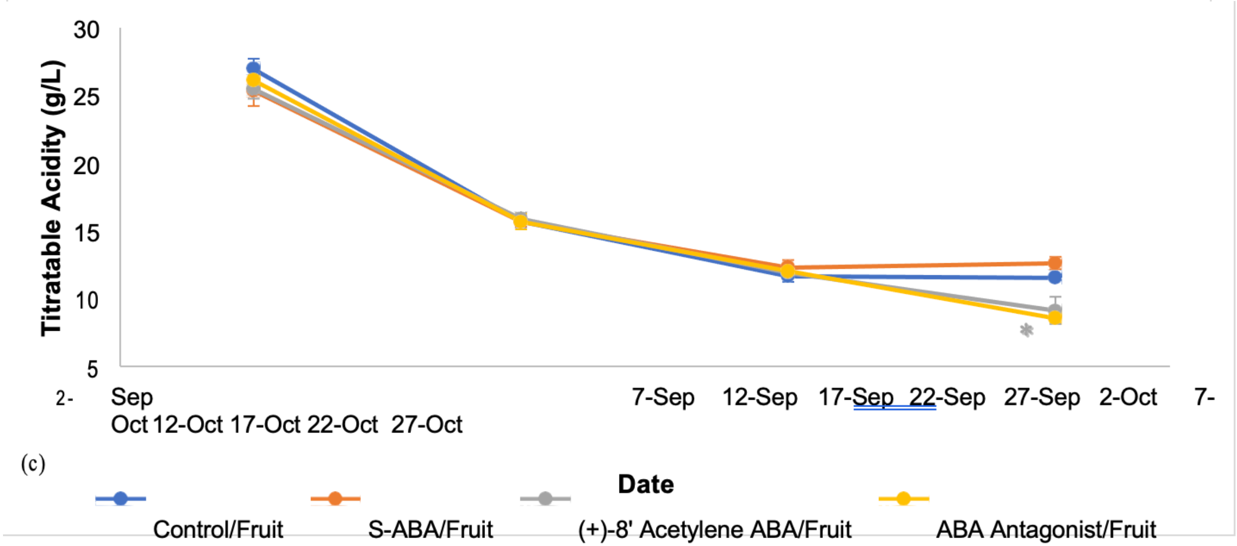
- **Each of the Cabernet Franc treatments were done in triplicate.**
  - Control/Canopy (Yellow)
  - Control/Fruit (Blue)
  - S-ABA/Fruit (Orange)
  - ABA 8’ Acetylene/Canopy (White)
  - ABA 8’ Acetylene/Fruit (Purple)
  - ABA Antagonist/Canopy (Yellow Dots)
  - ABA Antagonist/Fruit (Purple Stripes)

Treatment	Rate	Target Area
Control	0.05% Agral 90 (Surfactant)	Canopy and Fruit
Abscisic Acid	400 mg/L + 0.05% Agral 90	Fruit
ABA 8’ Acetylene	40 mg/L + 0.05% Agral 90	Canopy and Fruit
ABA Antagonist	10 mg/L + 0.05% Agral 90	Canopy and Fruit



Impacts of treatments applied to fruit
Fruit maturation
2019





Fruit composition at Harvest
Primary chemistry
2019

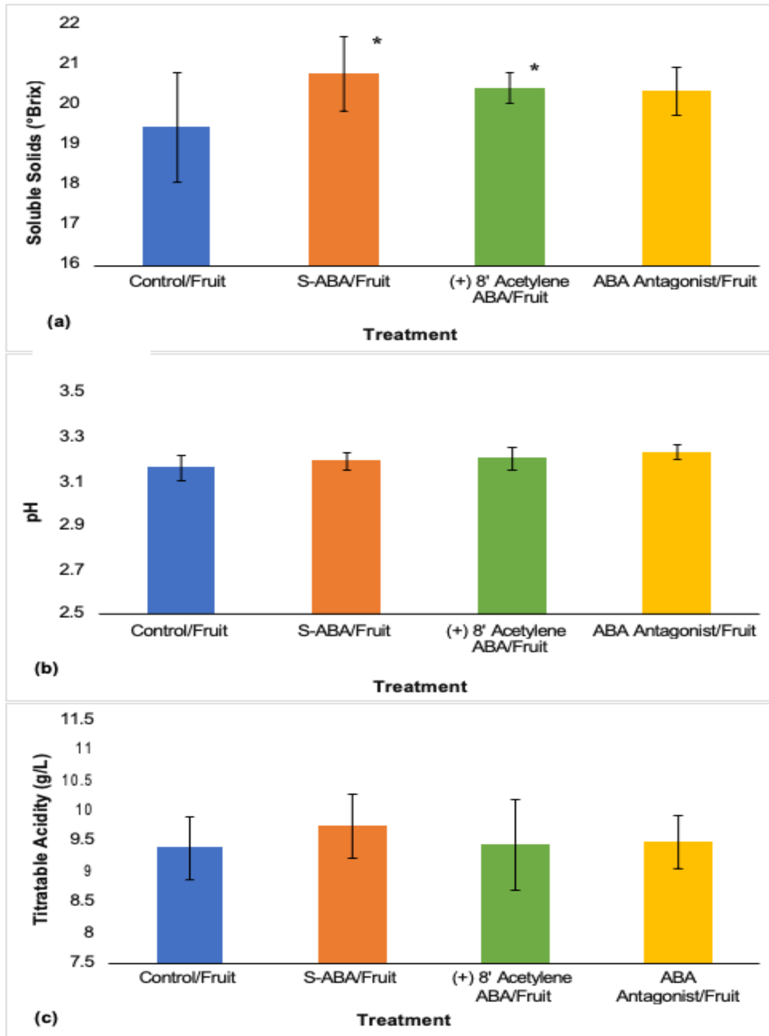


Figure 8: Basic chemical composition of (a) soluble solids; (b) pH; (c) titratable acidity from harvested Cabernet franc ABA fruiting zone treatments. * indicates statistical differences within the same application area against the control treatment using Dunnett's Test ($p<0.05$).

Fruit composition at Harvest
Total Phenolics and Anthocyanins
2019

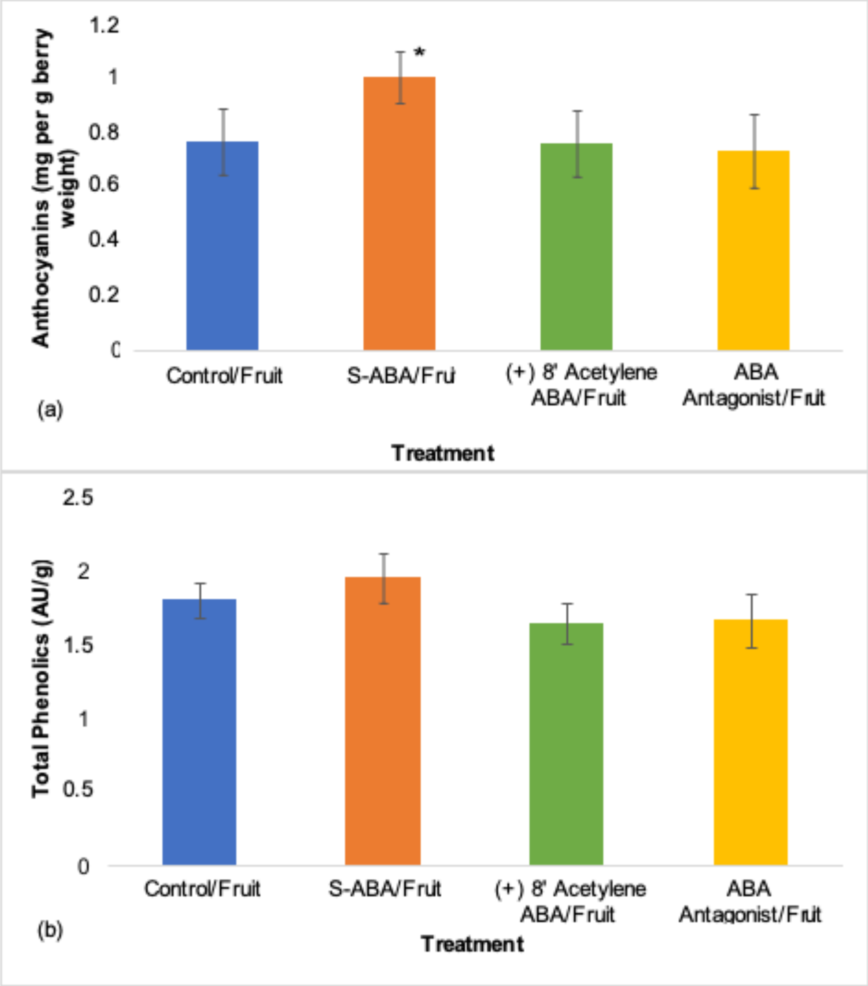
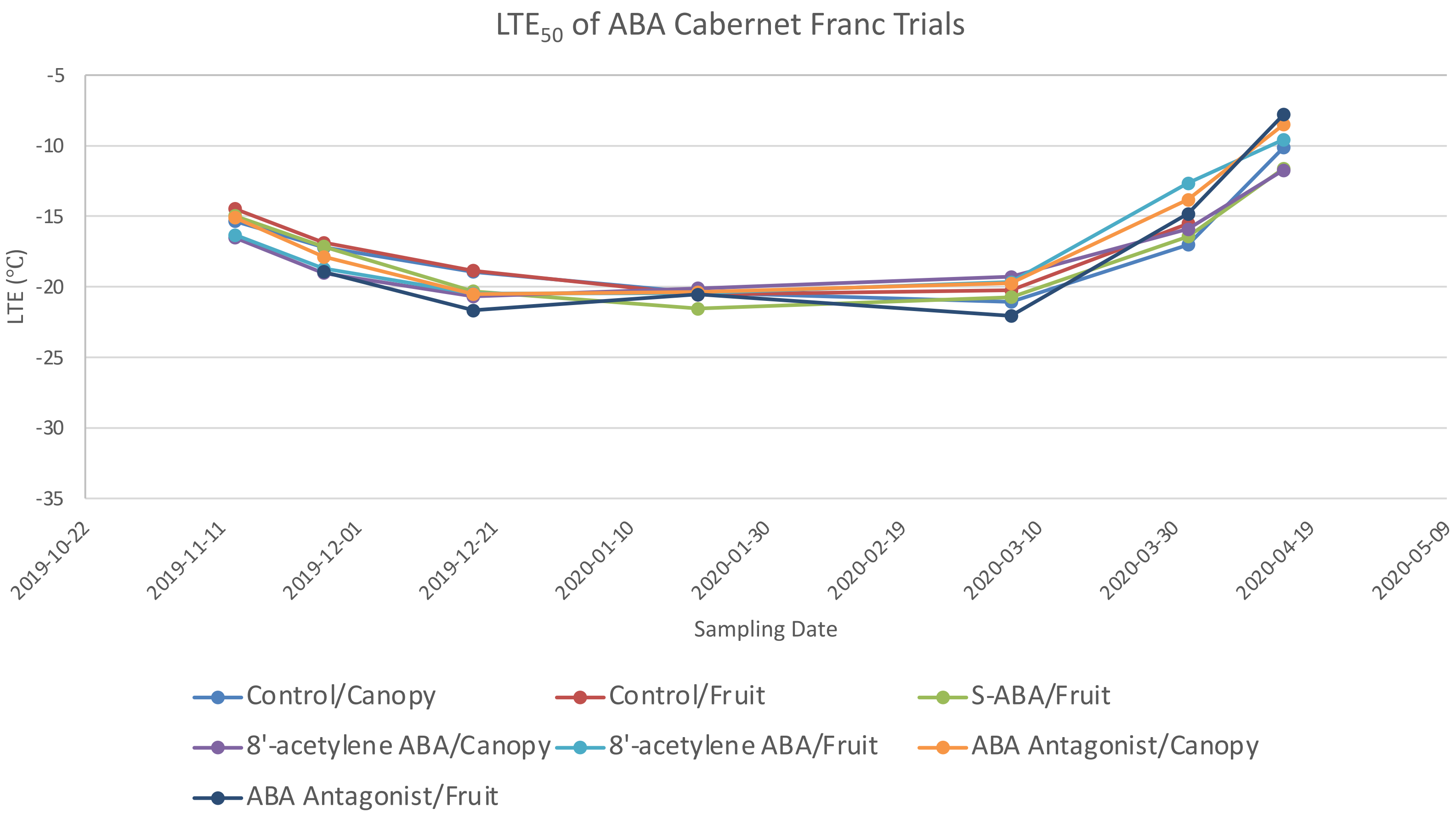


Figure 9: (a) Anthocyanin and (b) total phenolic composition of Cabernet franc treated ABA fruiting zone treatments. * indicates statistical differences within the same application area against the control treatment using Dunnett's Test ($p<0.05$).

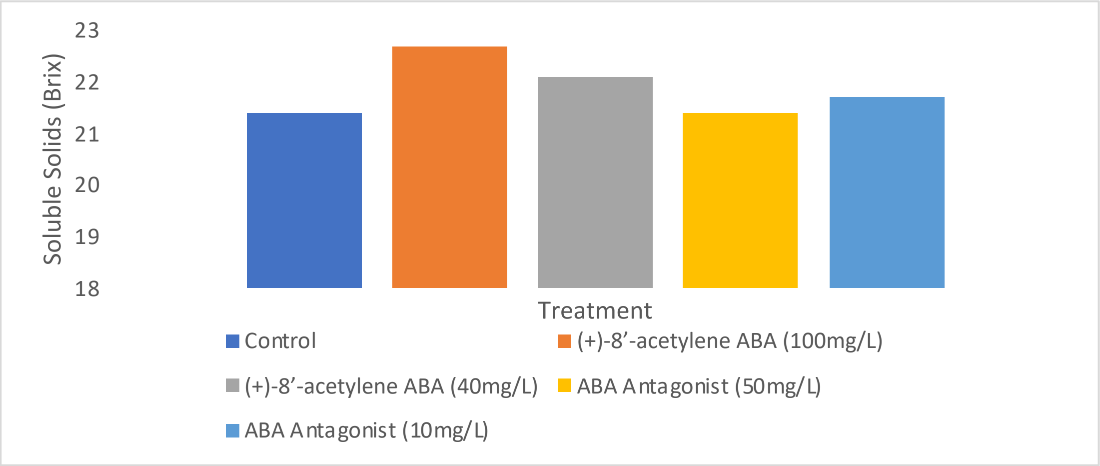
Cold tolerance and ABA and ABA applications GRBV Infected Cabernet Franc LTE_{50}

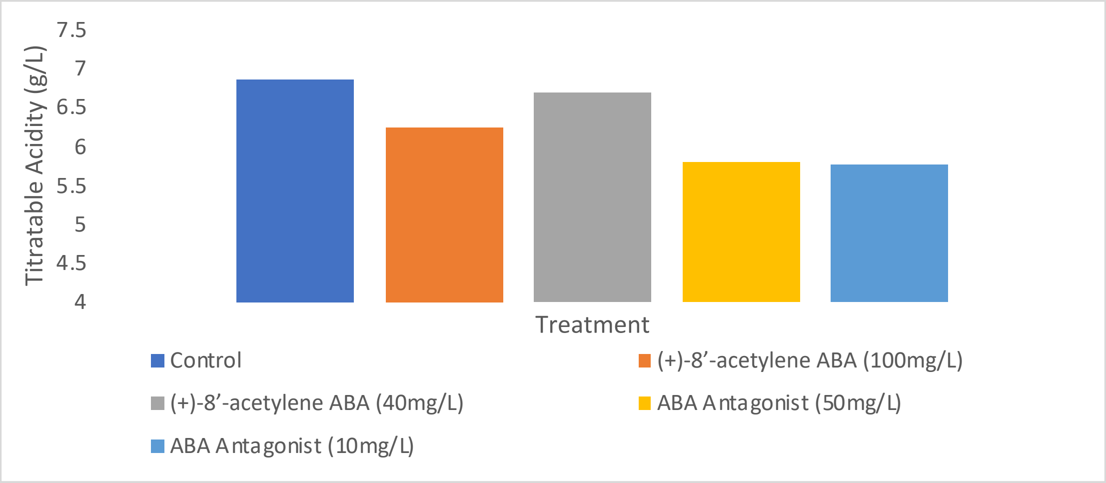


2020 Studies
Additional treatments

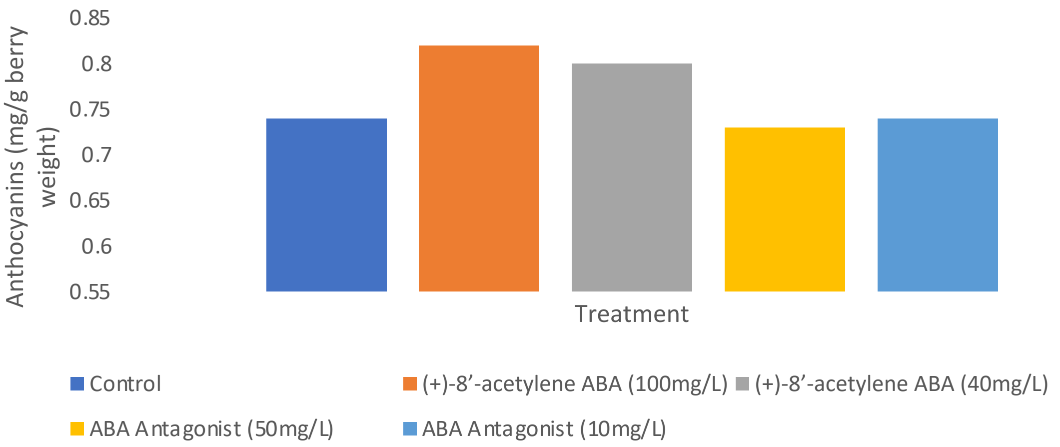
Treatment	Rate	Target Area
Control	0.05% surfactant (Agral 90)	Canopy and Fruit
S-ABA	400 mg/L + surfactant	Fruit
(+) 8’ Acetylene ABA	100 mg/L + surfactant	Canopy and Fruit
(+) 8’ Acetylene ABA	40 mg/L + surfactant	Canopy and Fruit
ABA Antagonist	50mg/L + surfactant	Canopy and Fruit
ABA Antagonist	10mg/L + surfactant	Canopy and Fruit

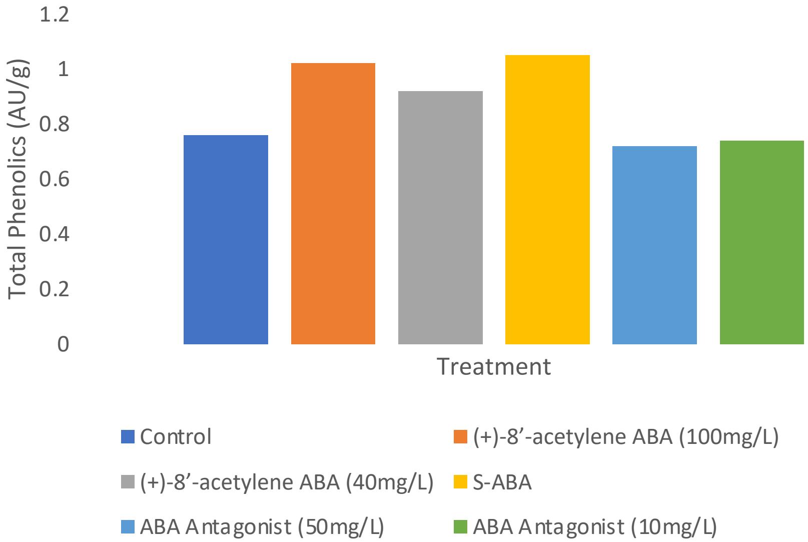
Fruit composition at Harvest
Primary chemistry
2020





Fruit composition at Harvest
Total Phenolics and Anthocyanins
2020





Conclusion

- ABA and ABA analogs may be a powerful tool to mitigate climate change risks

Reduce freeze injury due to:

- Enhanced dormancy and acclimation, slow unwanted deacclimation, reduce early bud break
- Form, concentration and timing can matter for desired effects

<u>Current studies and next steps</u>

- Alex Gunn (MSc student) has a project focused on the understanding the what and how's of ABA_A and improved hardiness of multiple cultivars
- Connecting dots on the physiological, biochemical and molecular levels

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