Going Viral

Update on Ontario Grape Virus Research

Wendy McFadden-Smith
OMAFRA
CCOVI Research Affiliate

Cool Climate Oenology & Viticulture Institute
Brock University

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Ontario

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- Willwerth crew
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Grape Leafroll Symptoms

- Starting in late Aug-early Sept at base of shoot and progressing up
- Downward curling of the leaf edges
- Interveinal reddening or yellowing
- Poor fruit maturation

Red Blotch Symptoms

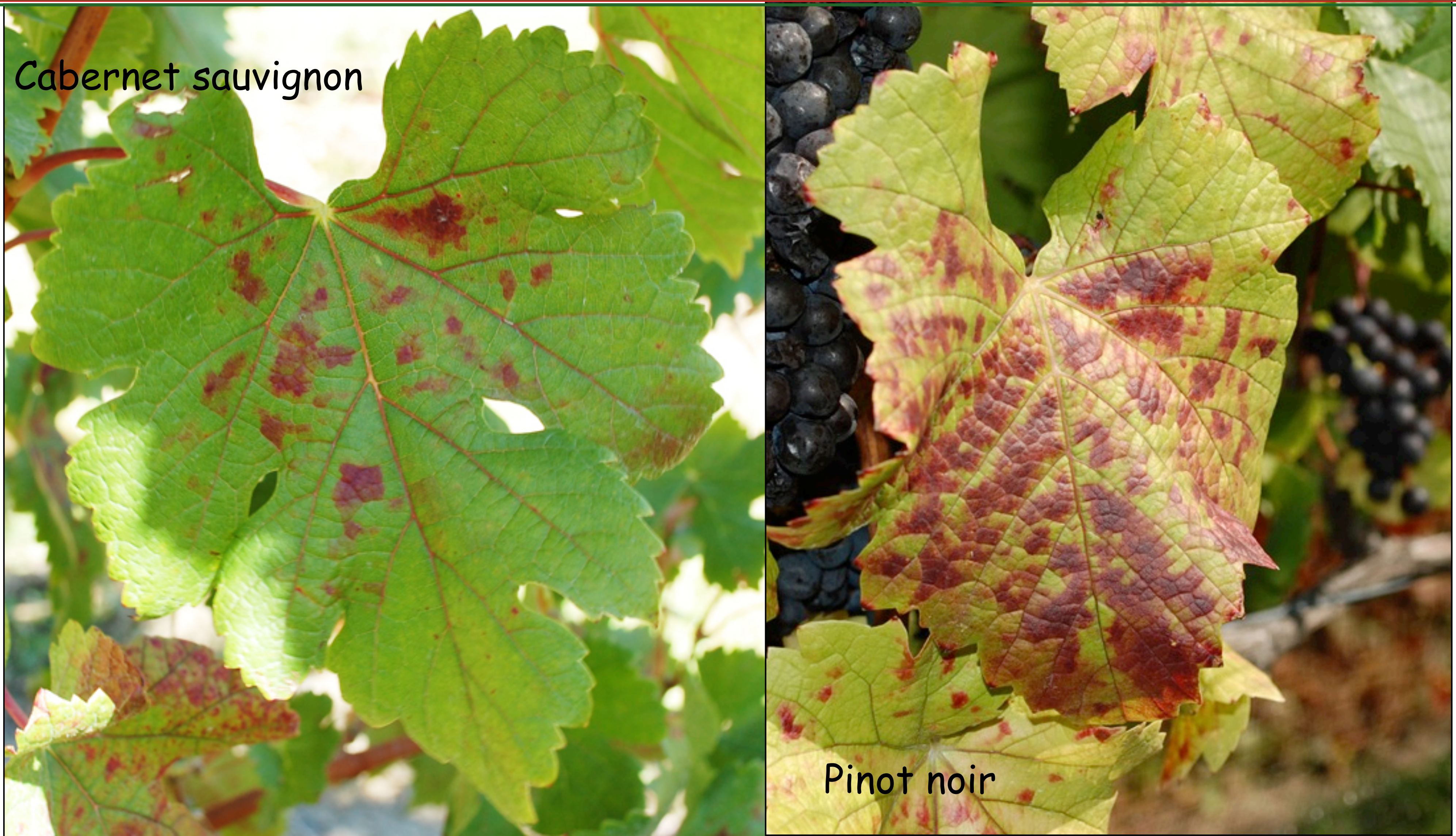
- Symptoms first appear in late Aug-early Sept
- No leaf rolling
- Red vinifera
  - Irregular pink to crimson blotches on blades starting on basal leaves
  - Secondary and tertiary veins turn red (BUT <u>inconsistent</u>!)
  - Occasional interveinal red between secondary veins
- White vinifera
  - Yellow margins, progressing to brown crispy margins

Red Blotch – Cabernet franc

Red blotch symptoms – Cabernet franc

Fuchs

Red blotch symptoms



Fuchs

Red blotch - Pinot noir

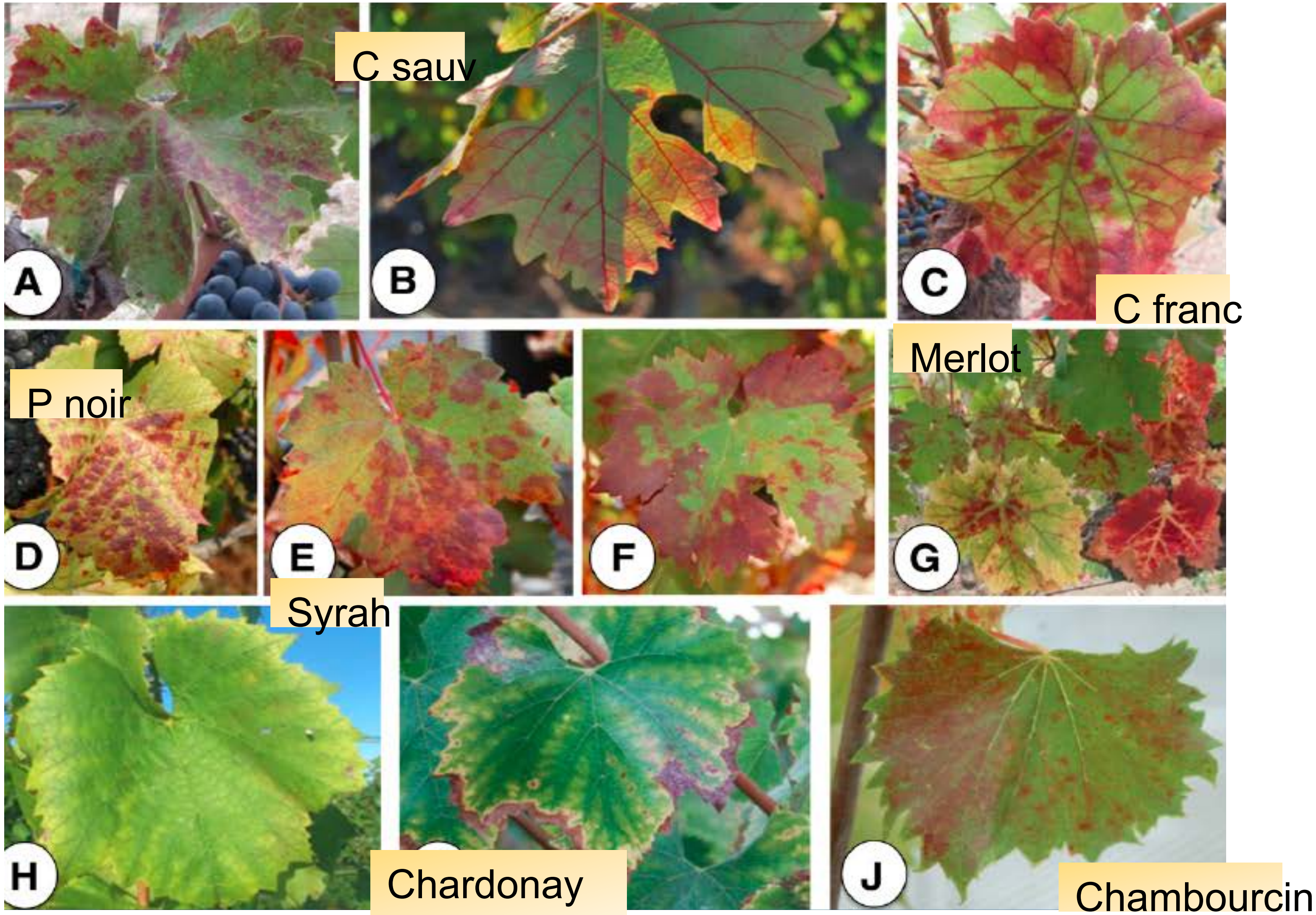
Symptomatic

Asymptomatic

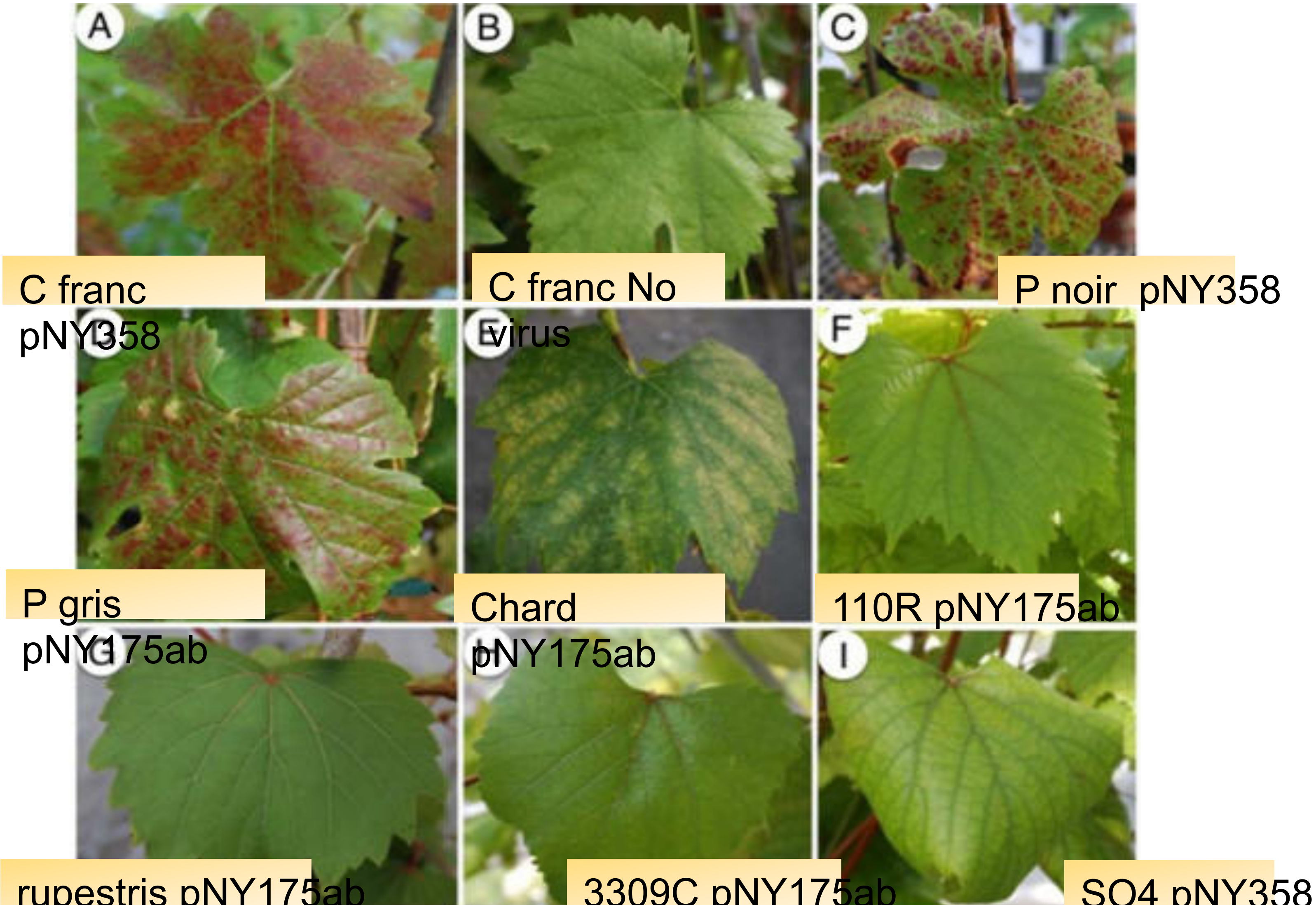
Red blotch – early symptoms Chardonnay

Red blotch – advanced symptoms Chardonnay

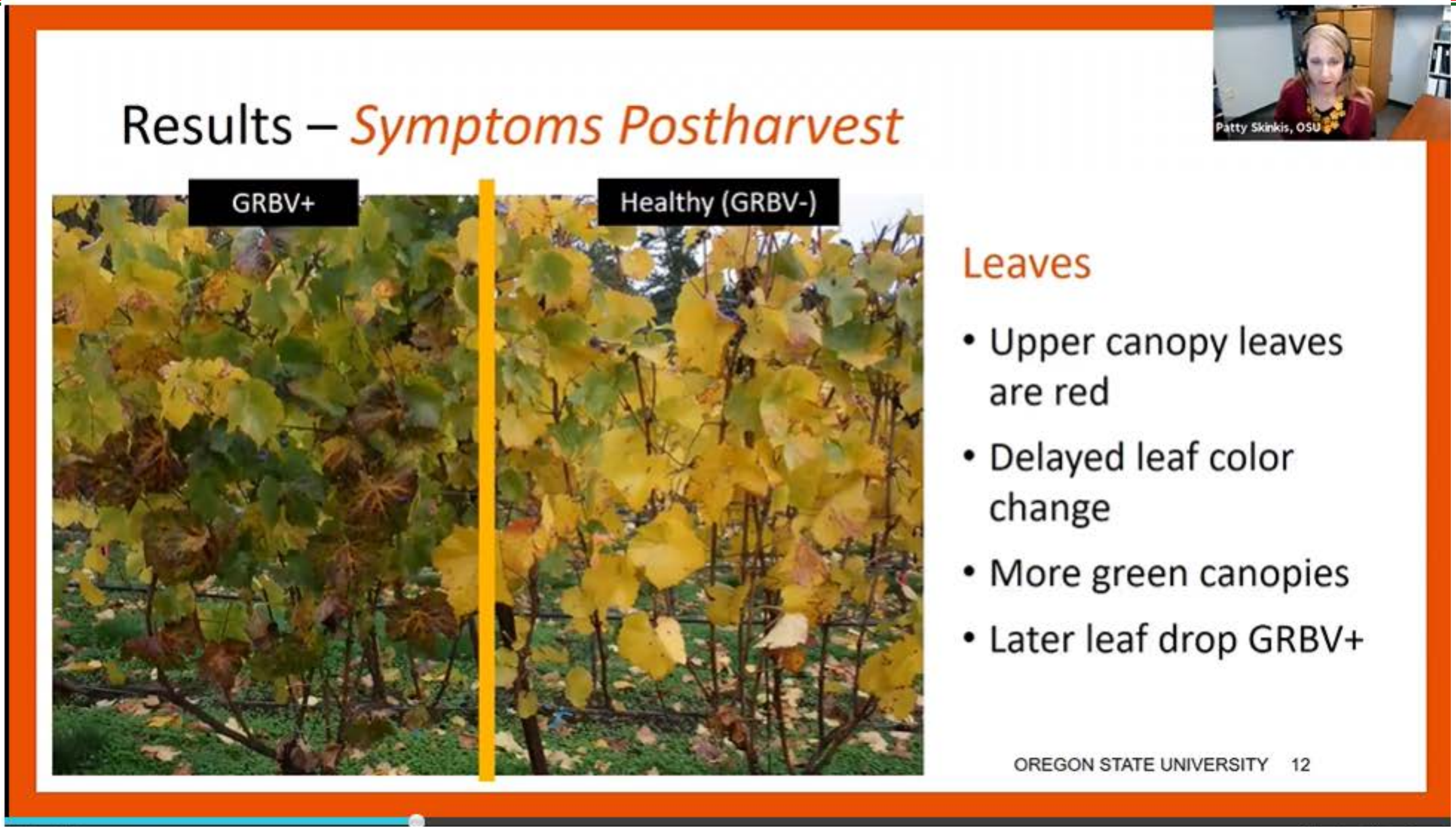
Variable symptoms of Red Blotch



Variable symptoms of Red Blotch



Red Blotch Symptoms



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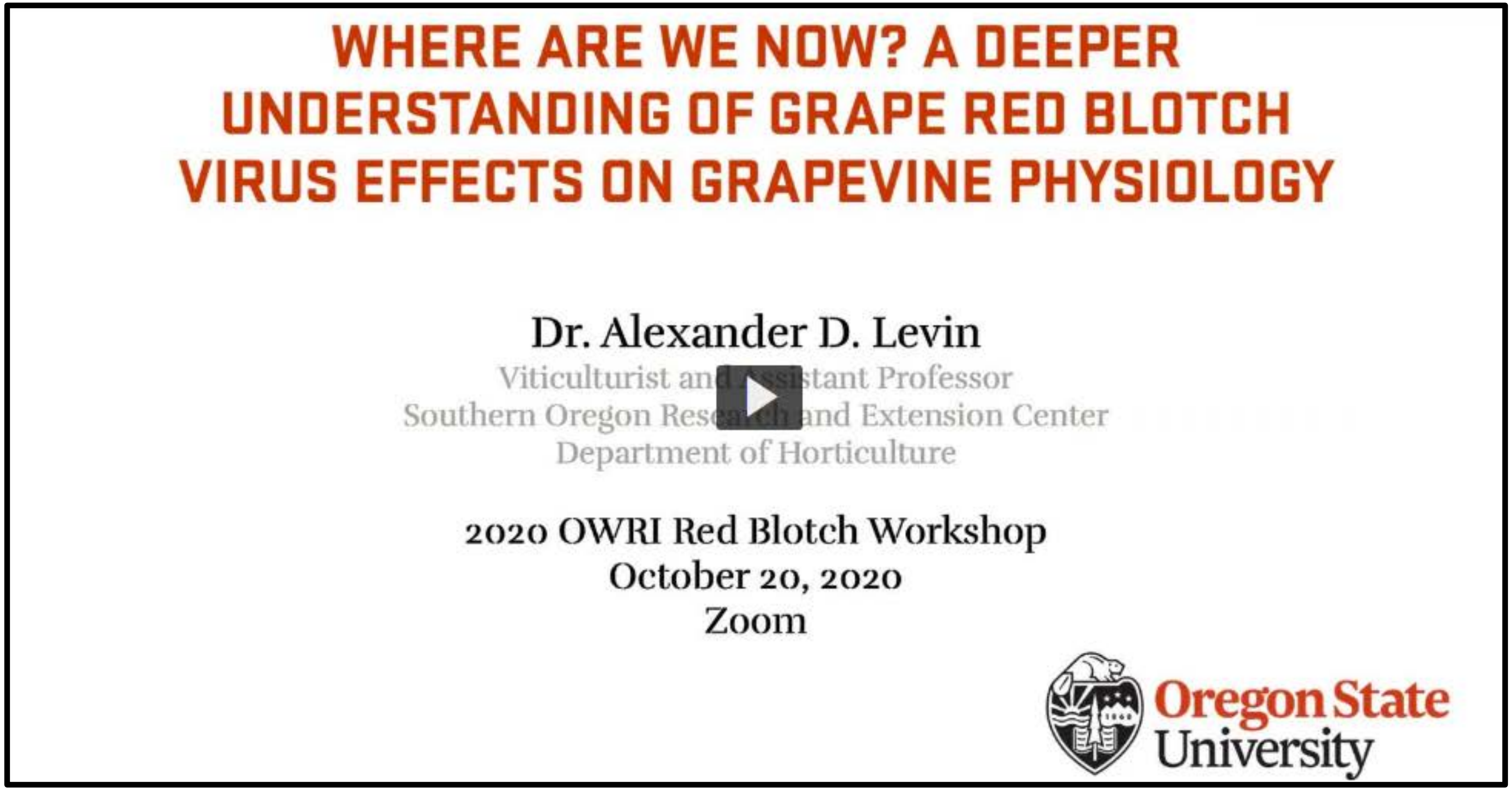
Symptom Expression Varies with Year

Effects on Vine Physiology

- Reduced photosynthesis and transpiration in leaves
- Reduced sugar movement out of leaves
- Increased leaf starch (@veraison and post-veraison)
- Triggers maturation of leaves
  - production of anthocyanins in reds, chlorosis in whites
- Larger berries – lower concentration of sugar
  - Secondary metabolism inhibited (e.g. anthocyanins)

For an indepth explanation on how GRBV affects vines:



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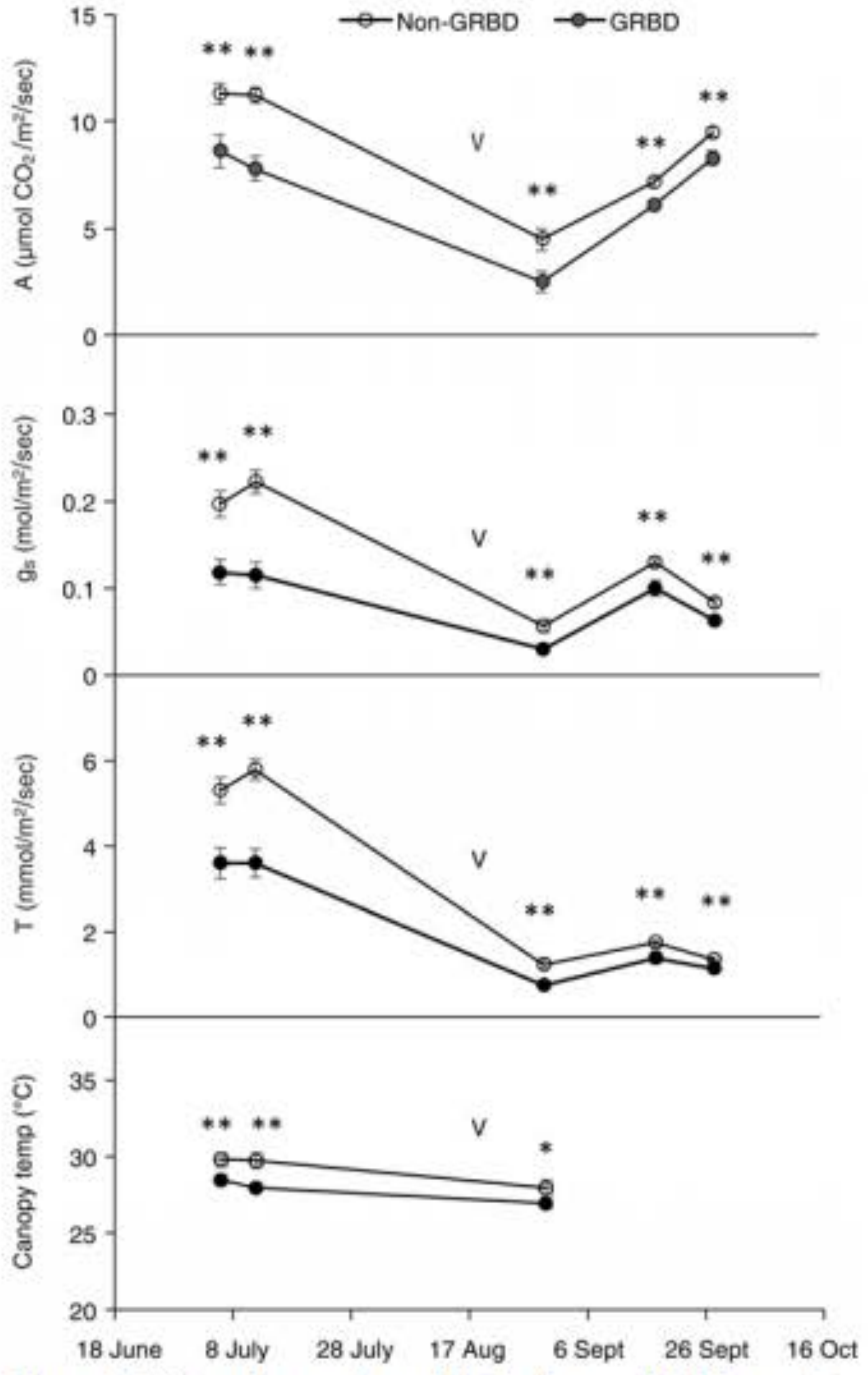
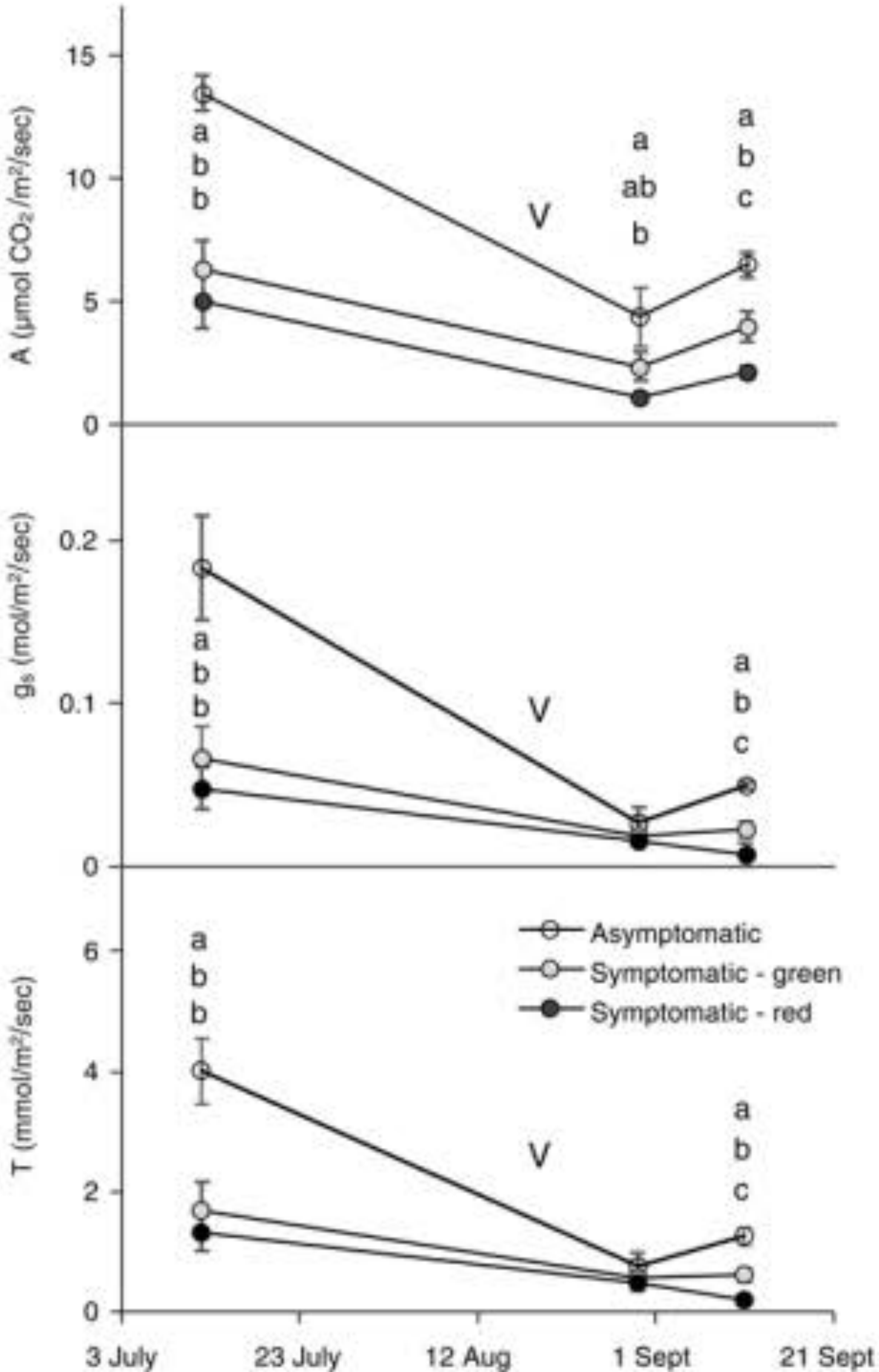


For an indepth explanation on how GRBV affects vines:

- Less CO_2
- Photosynthesis decreased
- Transpiration reduced

https://www.youtube.com/watch?v=DDIjPqaGG4Y

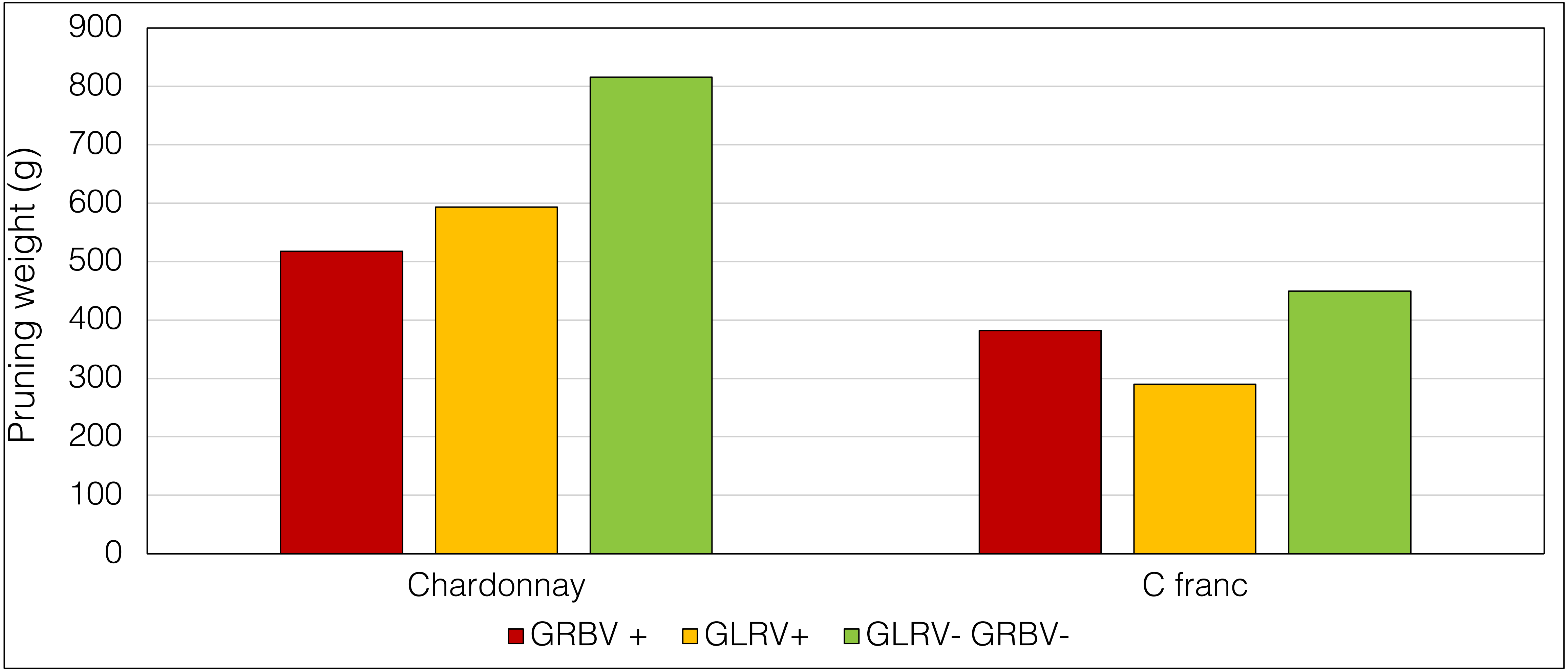


For an indepth explanation on how GRBV affects vines:

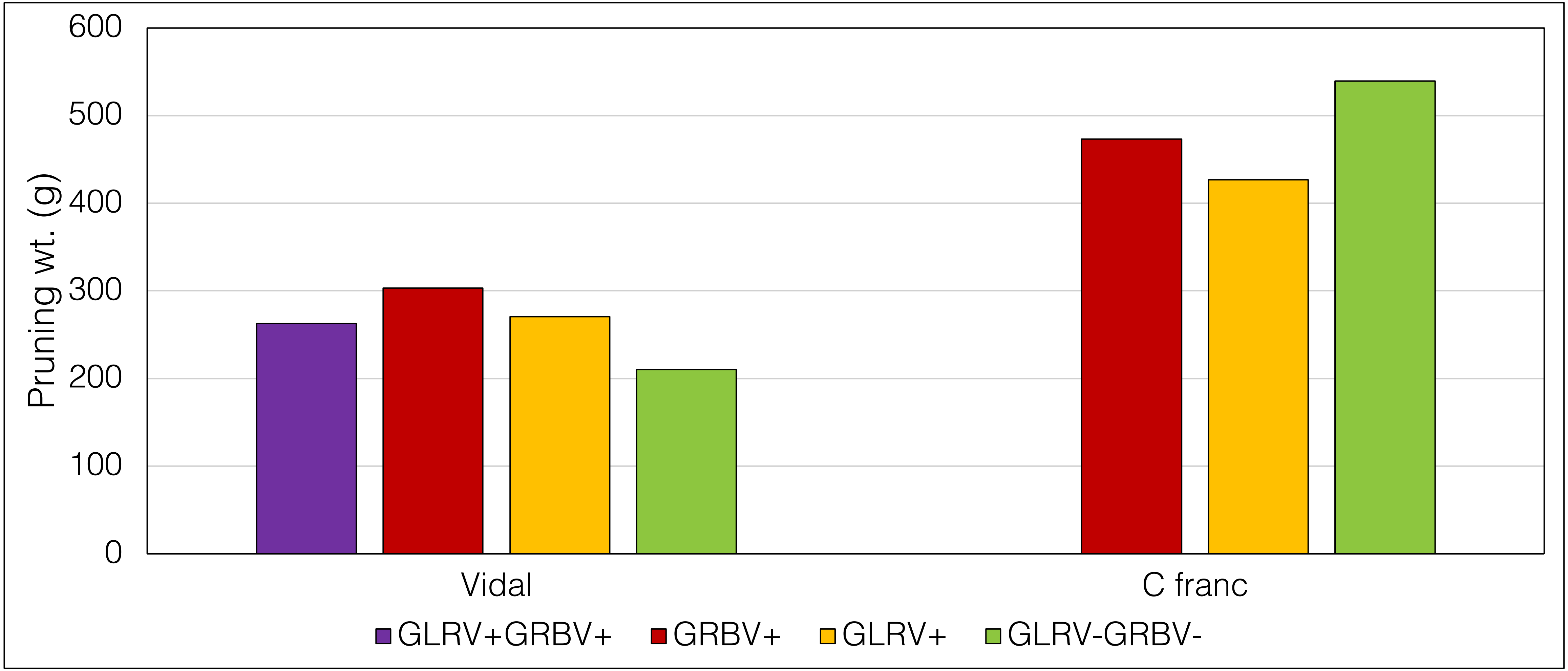
- Photosynthesis impacted in green areas of leaves with red symptoms with GRBV
- Also in asymptomatic leaves in vines with GRBV

https://www.youtube.com/watch?v=DDIjPqaGG4Y

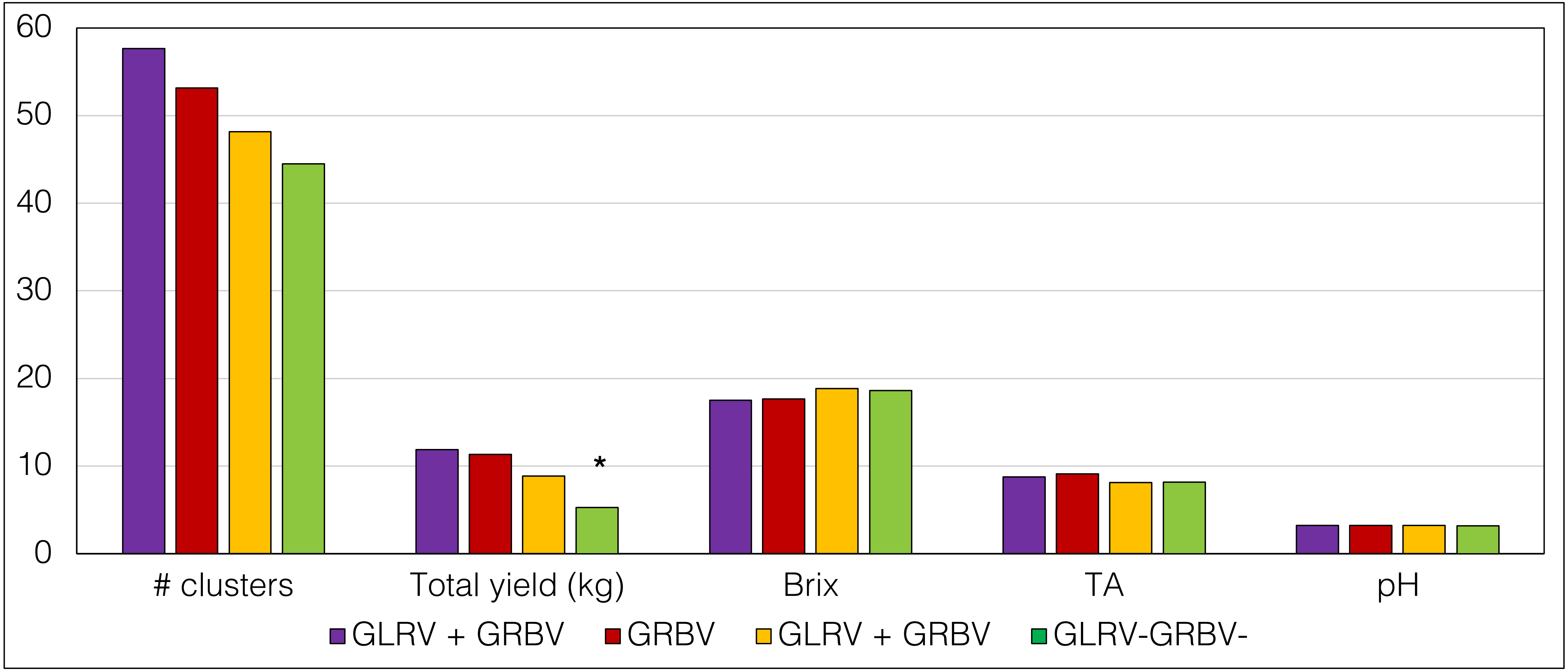
Vine Vigour, 2018-2019



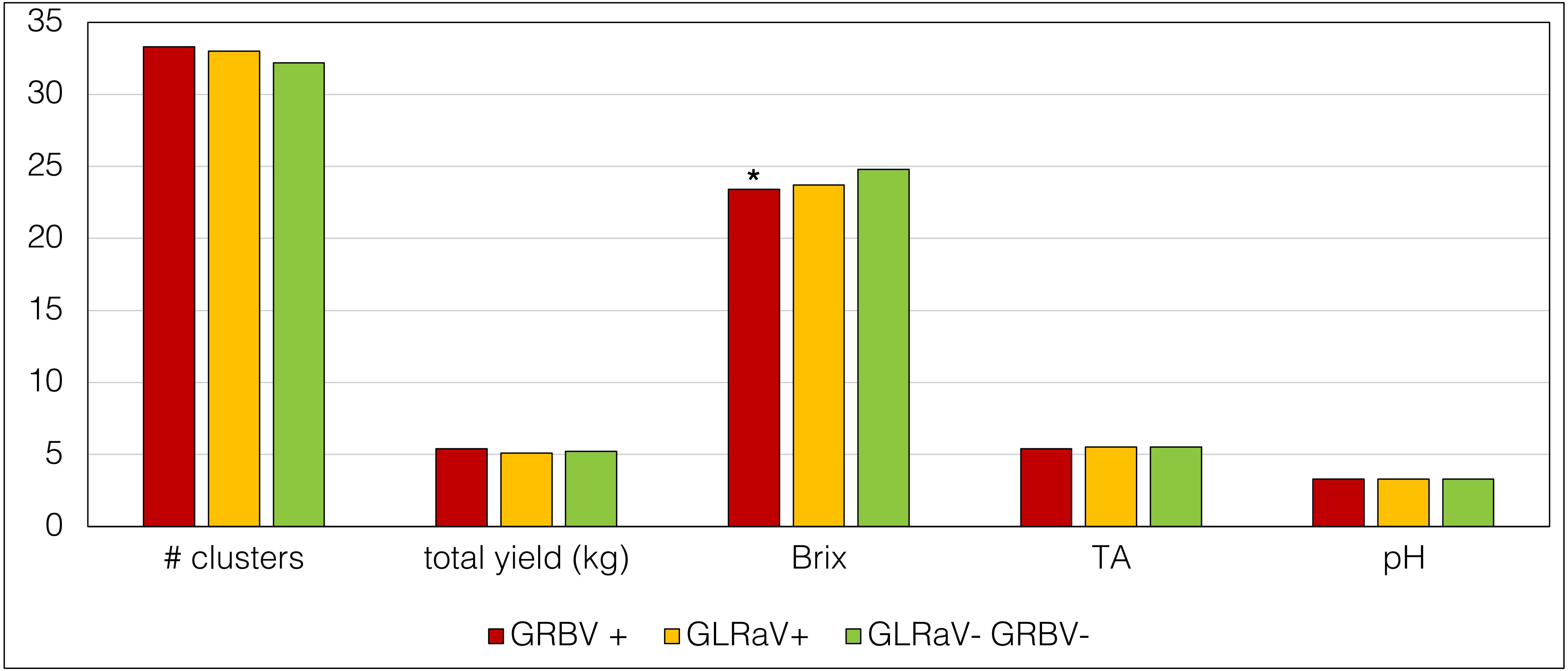
Vine Vigour, 2019-2020



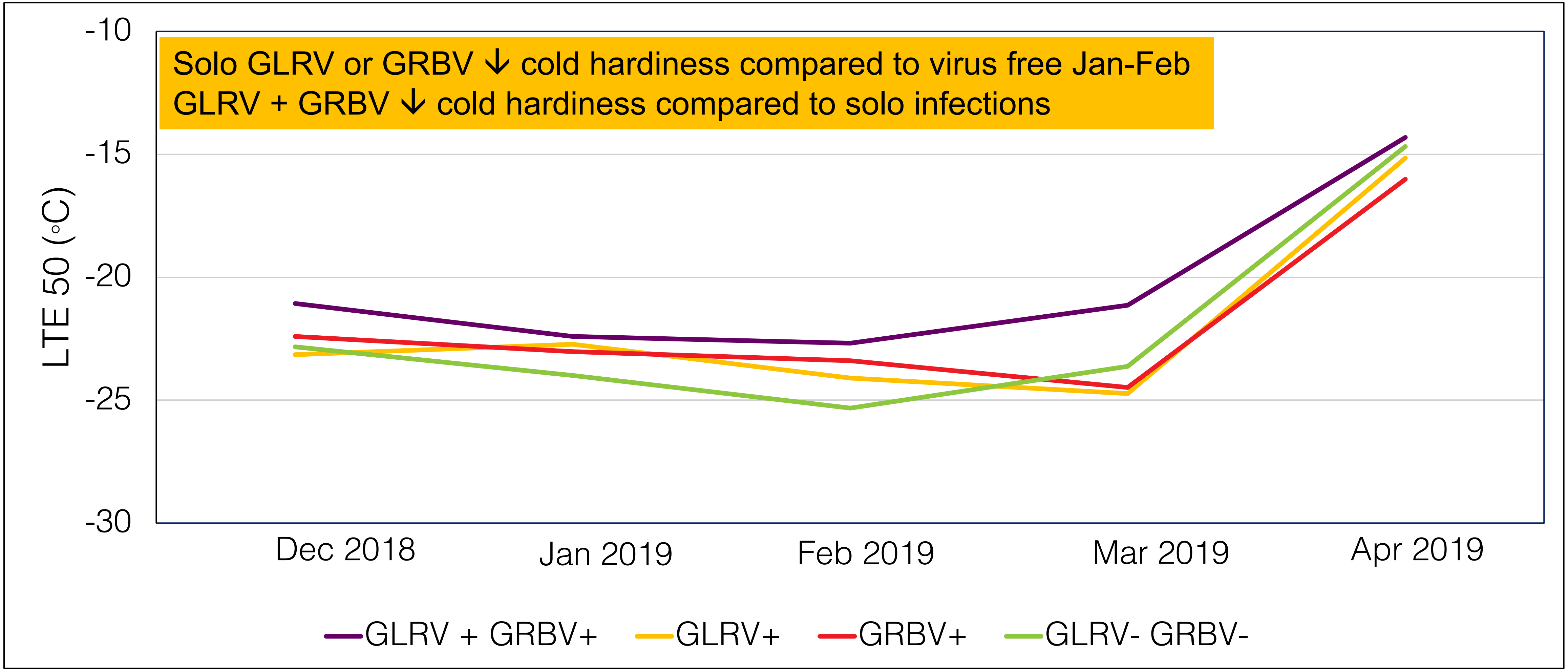
Harvest Parameters, Vidal, 2020



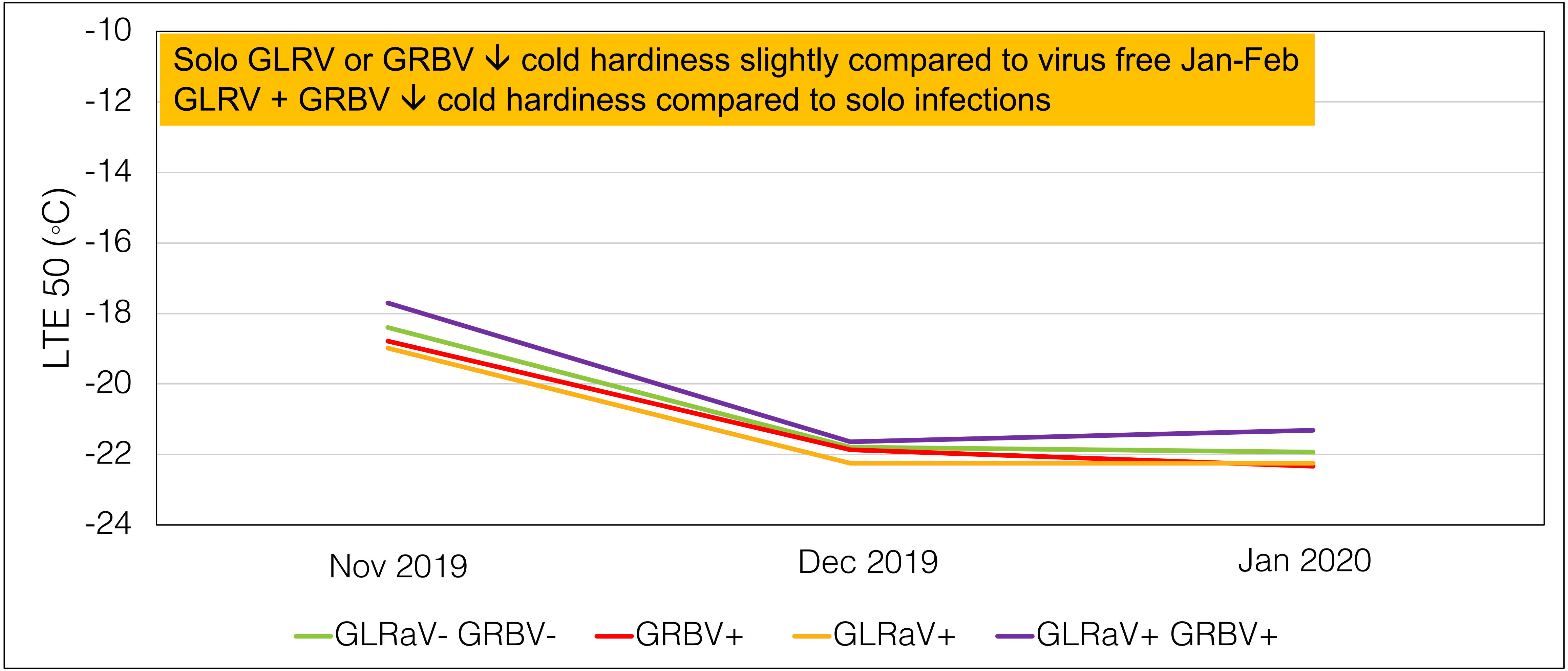
Harvest Parameters, Cabernet franc, 2020



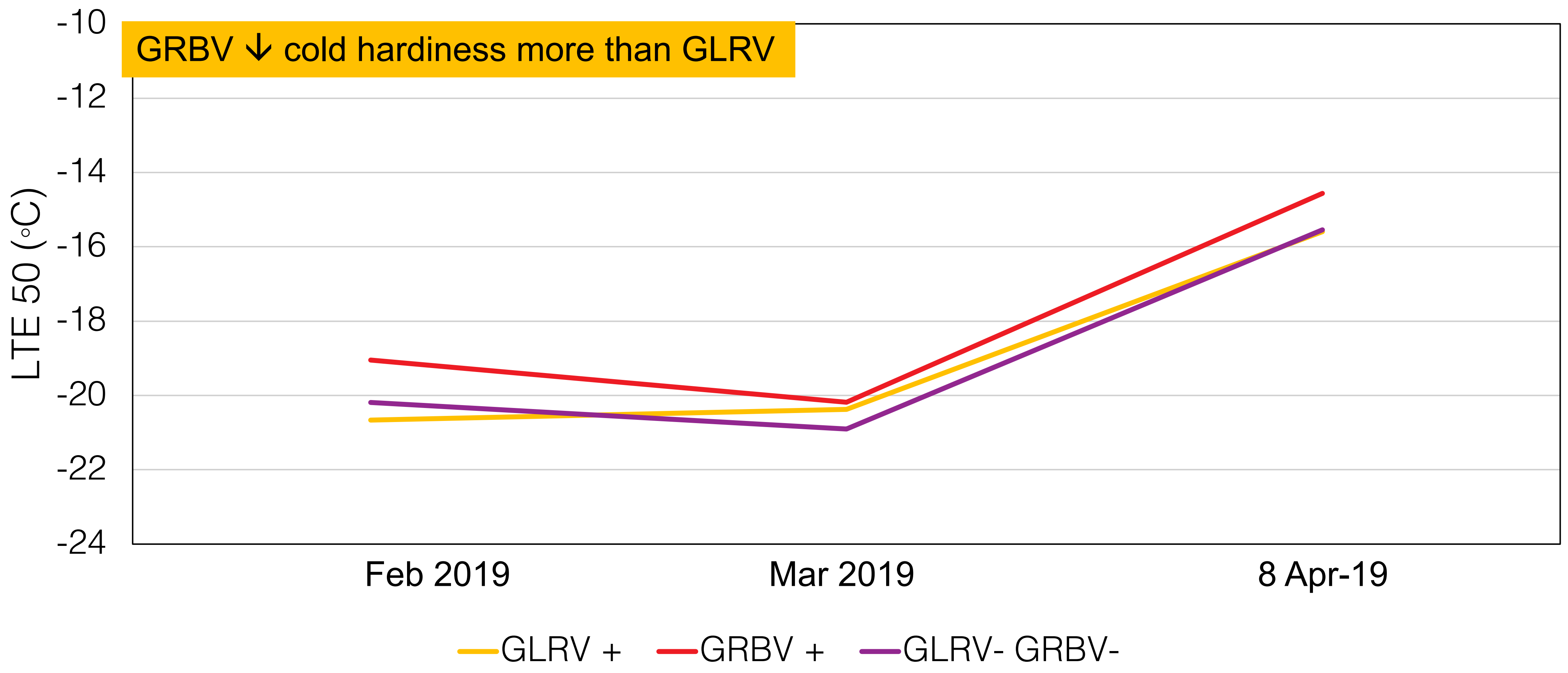
GLRaV-3 and GRBV – Effect on Cold Hardiness Chardonnay (2018-2019)



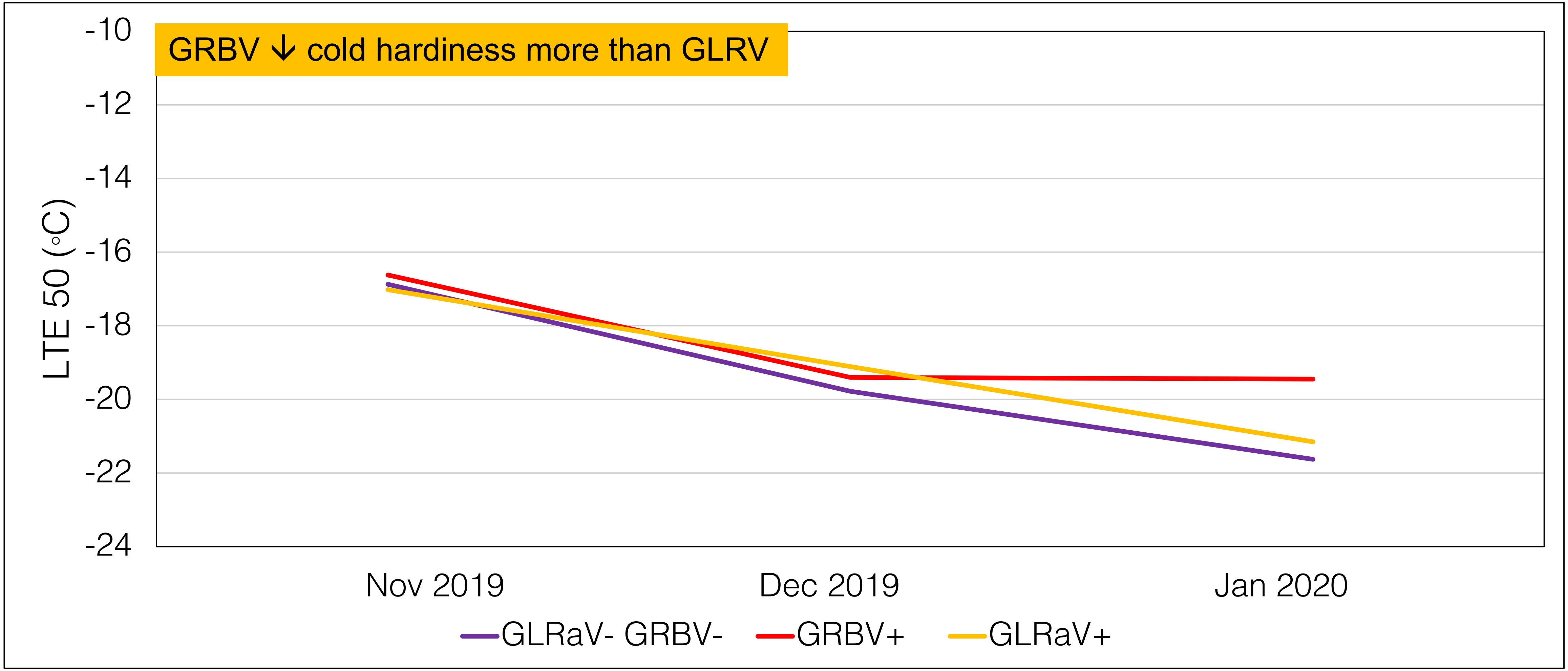
GLRaV-3 and GRBV – Effect on Cold Hardiness Chardonnay (2019-2020)



GLRaV-3 and GRBV – Effect on Cold Hardiness Cabernet franc (2018-2019)



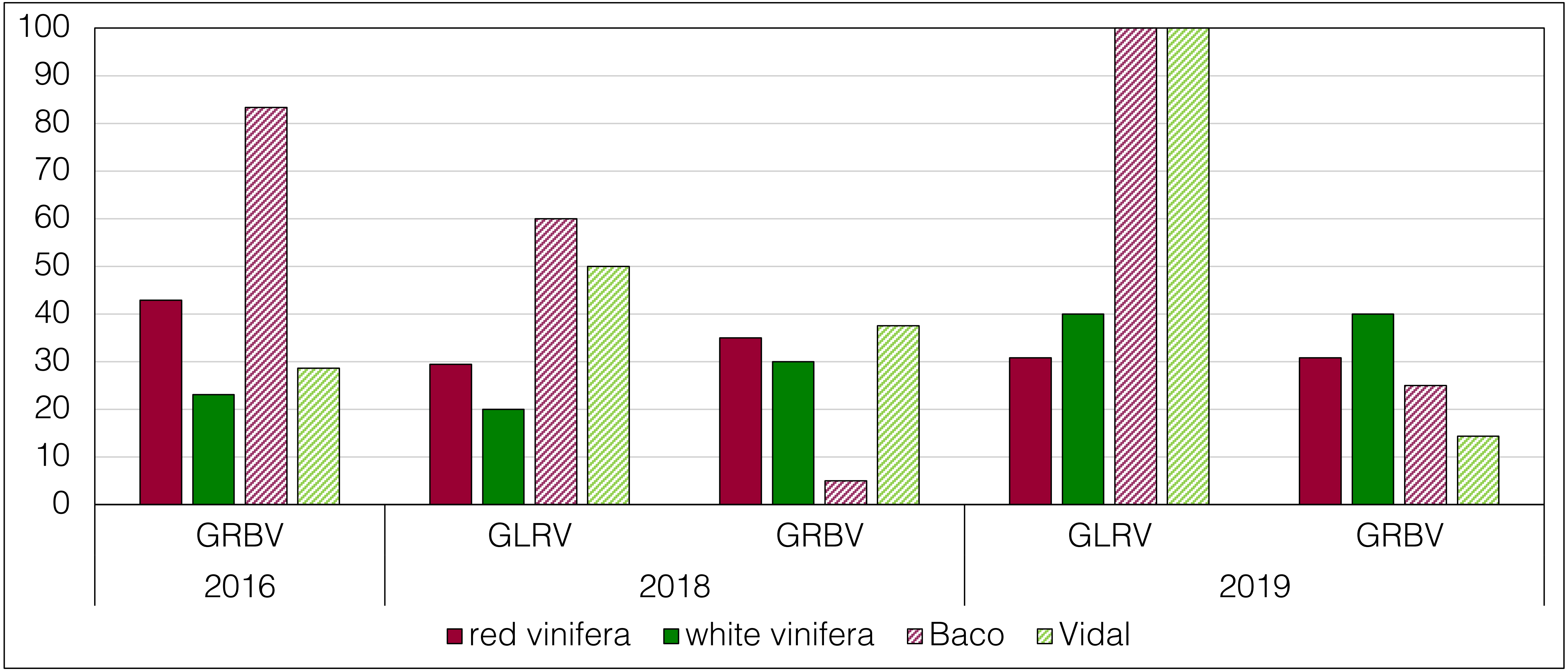
GLRaV-3 and GRBV – Effect on Cold Hardiness
Cabernet franc (2019-2020)



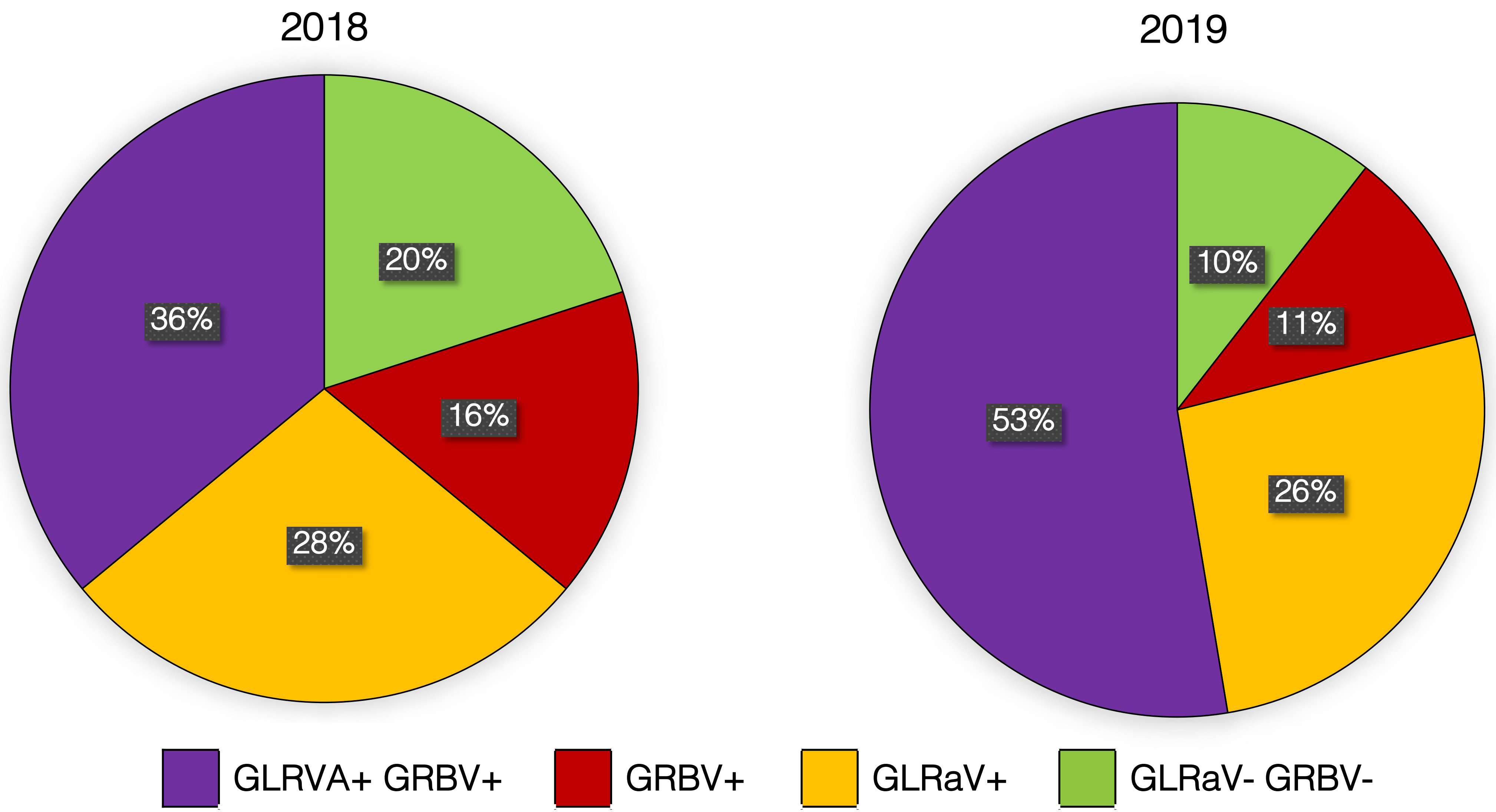
GLRaV-3 and GRBV in Ontario

- Questions:
  - How common GLRD and GRBD?
  - Effects of infection on cold hardiness?
  - Effects of co-infections?
  - Changes in distribution of infection over time? Vectors? Control?

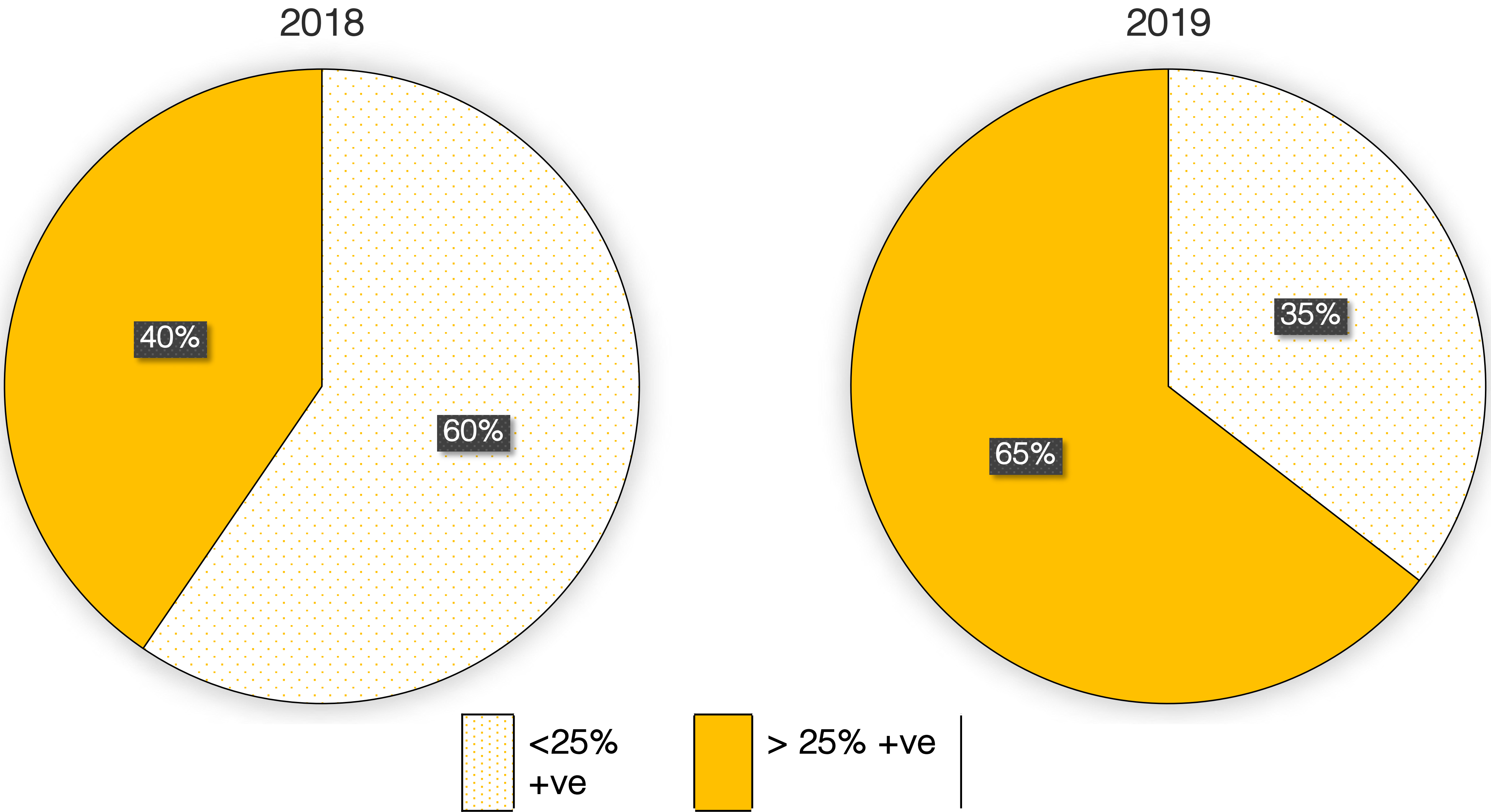
GLRV and GRBV % vineyard blocks sampled per year with > 25% incidence



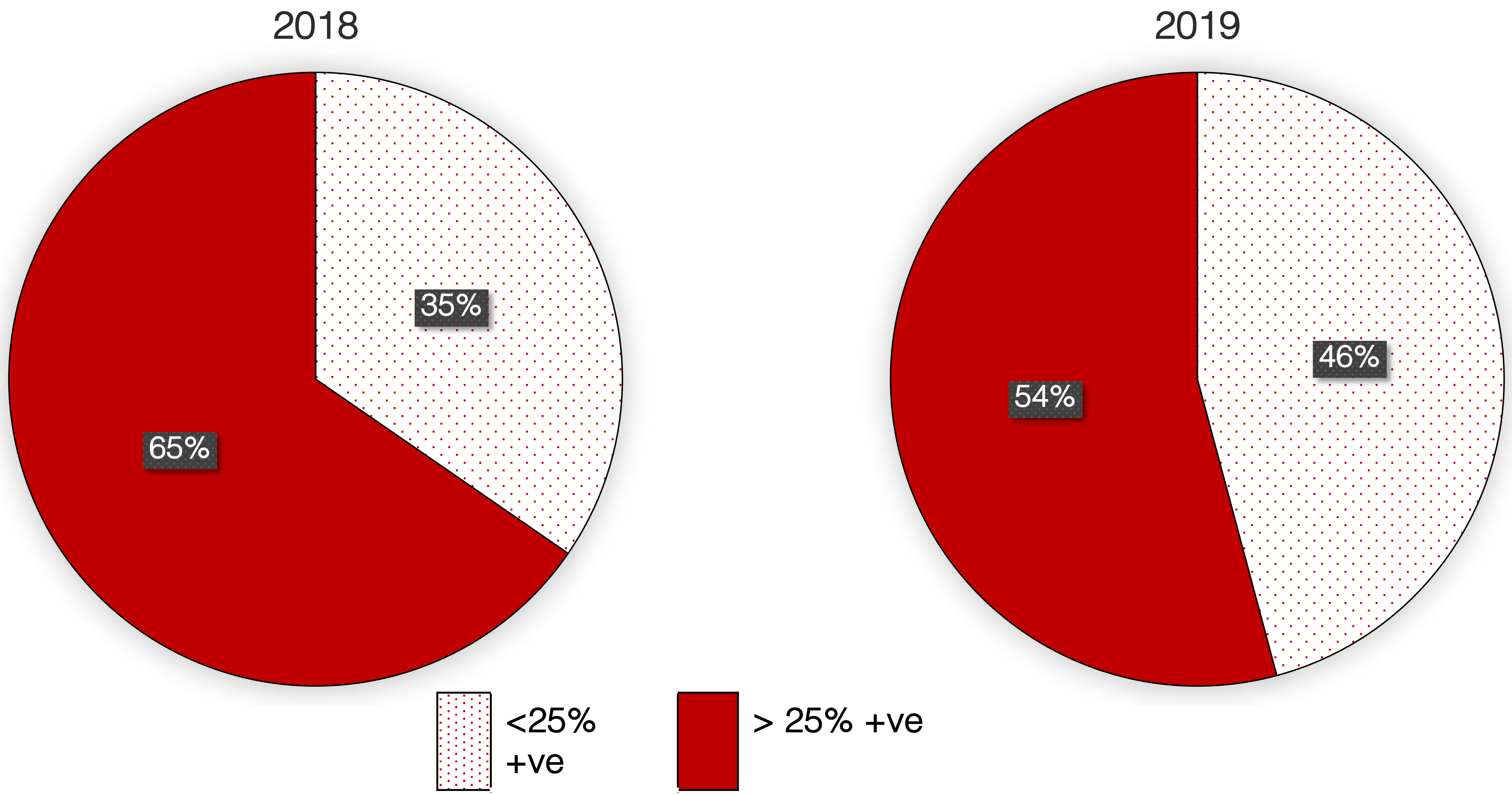
Incidence of GLRaV and GRBV, 2018 & 2019



GLRaV (solo or co-infection with GRBV), 2018 & 2019



GRBV (solo or co-infection) 2018 & 2019



Can we do anything to change the effects of viruses?

Crop thinning?	Little to no effect
Longer hang time?	No effect
K fertilizer?	Little to no effect
Irrigation?	Variable effect **Only with water deficit**

Department of Horticulture and Southern Oregon Research and Extension Center

SUPPLEMENTAL VINEYARD INPUTS MAY PARTIALLY MITIGATE NEGATIVE EFFECTS OF GRAPEVINE RED BLOTCH DISEASE IN OREGON PINOT NOIR

Cody Copp[1,2], Achala KC[2,3], and Alexander Levin[1,2]*

INTRODUCTION AND BACKGROUND

Since its discovery in 2008, Grapevine red blotch disease (GRBD) has been identified in winegrowing regions across the US (Al Rwahnih et al. 2013, Calvi 2011, Krenz et al. 2014). While progress has been made in understanding the virology and epidemiology (Bahder et al. 2016, Cieniewicz et al. 2017), few pragmatic solutions have been identified to manage the disease in the field. Removal of infected vines is currently the only solution to manage spread, but this costly strategy has only been proven economically advisable at high disease incidence levels (Ricketts et al. 2016). GRBD poses a considerable threat to wine grape production by altering vine physiology and berry ripening metabolism (Blanco-Ulate et al. 2017). Fruit from infected vines exhibits reduced total soluble solids (TSS) and lower anthocyanin concentration at harvest (Calvi 2011, Sudarshana et al. 2015), which may consequently reduce wine quality. Supplemental irrigation and fertilization may reduce vine stress to support photosynthetic and ripening processes compromised by GRBD. Crop thinning has been observed to increase TSS in vines infected with Grapevine leafroll virus, which causes GRBD-like symptoms (Kliewer and Lider 1976). This ongoing study will assess the efficacy of cultural practices in mitigating the negative effects of GRBD on fruit quality and may inform future management of GRBD in the vineyard.

MATERIALS AND METHODS

Vineyard site. This experiment is being conducted in two commercial *Vitis vinifera* L. cv. Pinot noir vineyard blocks located in the Rogue Valley AVA near Ashland, OR (42.1946°N, 122.7095°W). Blocks with more than 70% Grapevine red blotch virus (GRBV) infection in 2017 were chosen for the study. GRBV infection was confirmed with PCR at the beginning of the 2018 season. Control study vines that tested negative for GRBV in Spring 2018 tested positive in Fall 2018 and were excluded from analysis.

Experiment A. Pinot noir (777 clone) vines received a factorial combination of grower control (CON) and supplemental (SUPP; 2x CON) irrigation (I) and fertilization (F). Control irrigation and fertilization rates were determined by the grower-collaborator. Fertilizer was applied through the irrigation system three times during the growing season (27 June, 2 Aug., and 28 Aug.). CON-F rates applied were 11.5, 1.1, and 9.9 lbs. of N, P, and K per acre, respectively.

Experiment B. Pinot noir (Pommard clone) vines grafted to either Couderc 3309 (3309C) or Riparia Gloire (RG) rootstocks received factorial combinations of CON and SUPP irrigation and crop thinning (T; one cluster/shoot). Irrigation was imposed as in Experiment A. SUPP-T vines were thinned just after berry set on 21 June.

Disease Severity. Severity data was collected weekly after onset of symptoms. Symptom expression is quantified using the Horsfall-Barratt scale to categorize data into percentage ranges based on symptomatic tissues per vine (Bock et al. 2009). The midpoint values for the ranges were used for analysis.

Yield and Fruit composition. Fruit were sampled just prior to commercial harvest (October 1-2, 2018) for yield data and compositional analyses. Berries were weighed and pressed for juice which was centrifuged. Total soluble solids (TSS) were measured using a benchtop refractometer; pH and titratable acidity (TA) were determined using an auto-titrator. Additional berries were sampled for analysis of secondary metabolites (data not shown).

Analysis. Experiment A was analyzed using two-way analysis of variance (ANOVA) for split-plot randomized complete block design (RCBD). Experiment B was analyzed using two-way ANOVA for a split-plot RCBD for each rootstock. Means were separated using the Tukey-Kramer method (differences significant at $P < 0.05$).

Figure 1 Response of disease severity (% red leaves vine⁻¹) to supplemental fertilizer and irrigation (Experiment A); and to supplemental irrigation and crop thinning across two rootstocks (Experiment B).

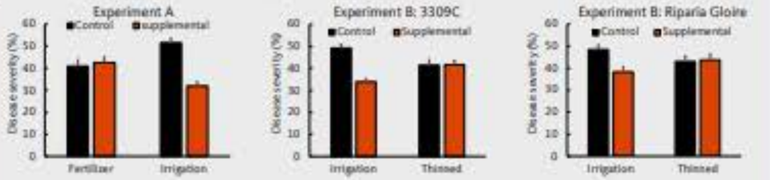


Table 1 Responses of yield components and berry composition at harvest to irrigation and fertilizer (Experiment A) in GRBV-infected vines. Values followed by the same letter are not significantly different at $P<0.05$.

Irrigation	Fertilizer	Yield (kg vine⁻¹)	Cluster weight (g)	Berry weight (g)	TSS (°Brix)	pH	TA (g L⁻¹)
CON	CON	3.23 ab	140.9 a	1.17 a	21.0 a	3.53 ab	3.52 a
	SUPP	2.81 a	135.6 a	1.16 a	21.2 a	3.61 c	3.61 a
SUPP	CON	3.90 b	155.1 a	1.27 a	20.3 a	3.49 a	3.90 a
	SUPP	3.74 b	149.8 a	1.26 a	20.4 a	3.56 bc	3.99 a

Table 2 Responses of yield components and berry composition at harvest to supplemental irrigation and crop thinning (Experiment B) in GRBV-infected vines grown on two rootstocks. Values followed by the same letter are not significantly different at $P<0.05$.

Rootstock	Irrigation	Thinning	Yield (kg vine⁻¹)	Cluster weight (g)	Berry weight (g)	TSS (°Brix)	pH	TA (g L⁻¹)
3309C	CON	CON	3.71 bc	160.2 a	1.29 ab	24.4 a	3.80 b	3.17 ab
		SUPP	2.34 a	164.8 a	1.32 ac	24.6 a	3.94 c	2.82 a
	SUPP	CON	4.27 c	181.6 a	1.42 cd	24.9 a	3.65 a	4.01 c
		SUPP	2.90 ab	186.2 a	1.45 bd	25.1 a	3.79 b	3.67 bc
Riparia Gloire	CON	CON	2.98 b	153.0 a	1.01 a	23.1 a	3.72 a	2.92 a
		SUPP	2.35 a	177.6 a	1.27 b	24.4 a	3.88 b	2.73 a
	SUPP	CON	3.79 c	169.0 a	1.26 ab	22.9 a	3.72 ab	3.50 a
		SUPP	3.16 b	193.5 a	1.30 ab	23.2 a	3.79 ab	3.30 a

RESULTS AND DISCUSSION

Disease Severity. In both experiments, SUPP-I significantly reduced disease severity at harvest. Disease severity decreased as a function of irrigation by 19.6% in Experiment A and by 15.2 and 10.0% in Experiment B for 3309C and RG, respectively. Fertilizer and crop thinning had no effect on disease severity across treatment groups.

Yield Components. Yield per vine increased with supplemental irrigation by 27% in Experiment A and by 20 and 30% in Experiment B (for 3309C and RG respectively). In Experiment A, there was a slight (not significant) increase in berry weight in the SUPP-I treatments. There were no other significant treatment effects on cluster weight or berry weight in either experiment. SUPP-F had no significant effect on any of the yield components in Experiment A.

Berry Composition. There were no significant treatment effects on TSS at harvest in either experiment. However, SUPP-F treatments in Experiment A and three of the four SUPP-T treatments in Experiment B had significantly increased berry pH when compared to the controls. SUPP-F increased pH by an average of 0.09 pH units over CON-F treatments in Experiment A. SUPP-T increased pH by an average of 0.14 and 0.12 pH units for 3309C and RG, respectively, over CON-T treatments in Experiment B. TA did not significantly change between treatments for Experiment A, but TA did trend higher for the treatments receiving SUPP-I over CON-I treatments. In Experiment B, 3309C vines that received SUPP-I had a statistically significant increase in TA at harvest while RG vines showed no significant difference in TA.

CONCLUSIONS

The first year's data suggest that increasing irrigation in GRBV-positive vines can decrease GRBD disease severity and increase vine productivity without reducing fruit quality. In contrast, increasing fertilization or decreasing crop load had no impact on disease severity, and somewhat reduced fruit quality under the conditions of this study. Furthermore, while the positive impacts of irrigation were conserved across both rootstocks in Experiment B, the negative impacts of thinning were slightly more pronounced in 3309C compared to RG, suggesting that there may be genetic differences in infected-vine response to cultural practices. Continued analysis of vegetative growth and fruit secondary metabolites will further inform the efficacy of cultural practices in mitigating the effects of GRBD on vine health, productivity, and fruit quality.

LITERATURE CITED

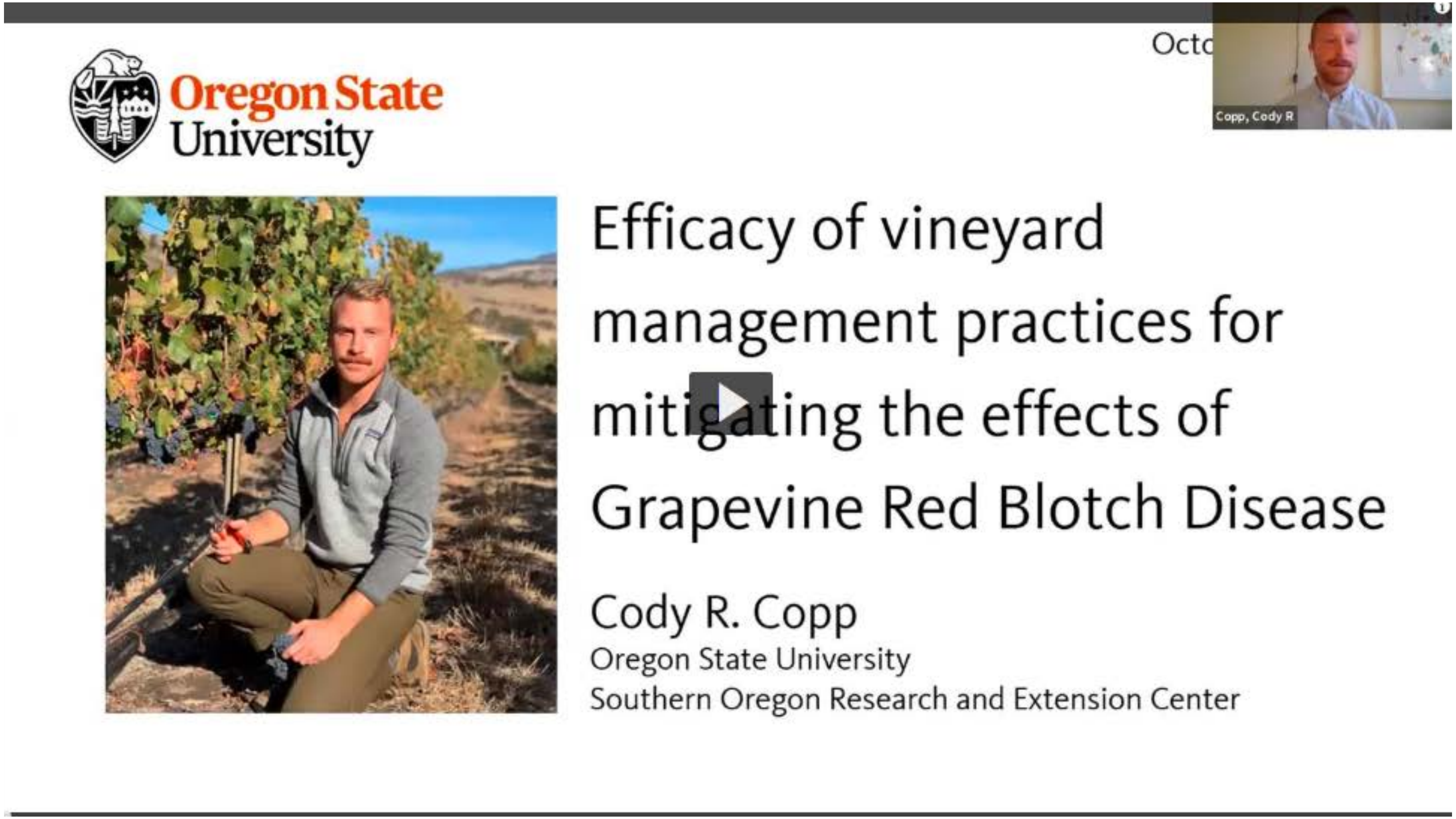
ACKNOWLEDGEMENTS

- Oregon Department of Agriculture
- Rogue Valley Winegrowers Association
- Oregon Wine Research Institute
- Agricultural Research Foundation
- Oregon Wine Board
- Belle Fiore Winery
- Results Partners, LLC

Oregon State University

https://www.researchgate.net/profile/Alexander_Levin4/publication/335843063_Supplemental_Vineyard_Inputs_May_Partially_Mitigate_Negative_Effects_of_Grapevine_Red_Blotch_Disease_in_Oregon_Pinot_noir/links/5d7ffcd9299bf10c1ab2429b/Supplemental-Vineyard-Inputs-May-Partially-Mitigate-Negative-Effects-of-Grapevine-Red-Blotch-Disease-in-Oregon-Pinot-noir.pdf

More info on impact of cultural practices vs GRBV



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More info on impact of cultural practices vs GRBV

https://media.oregonstate.edu/media/t/1_f77n9lay

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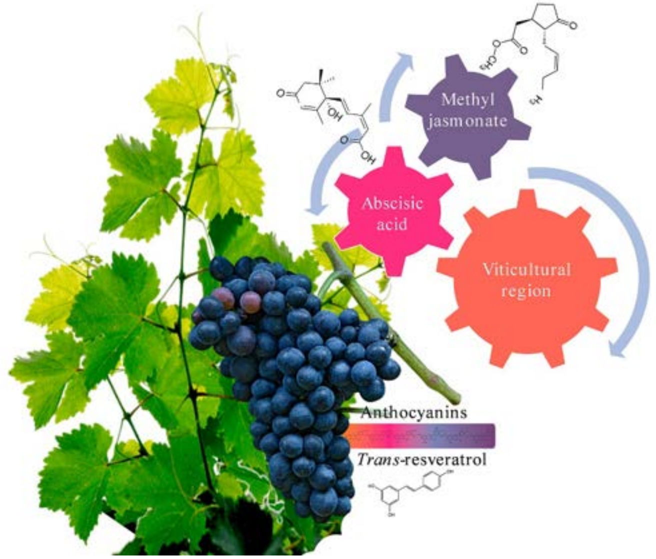
A possible Hormonal Link to GRBD?

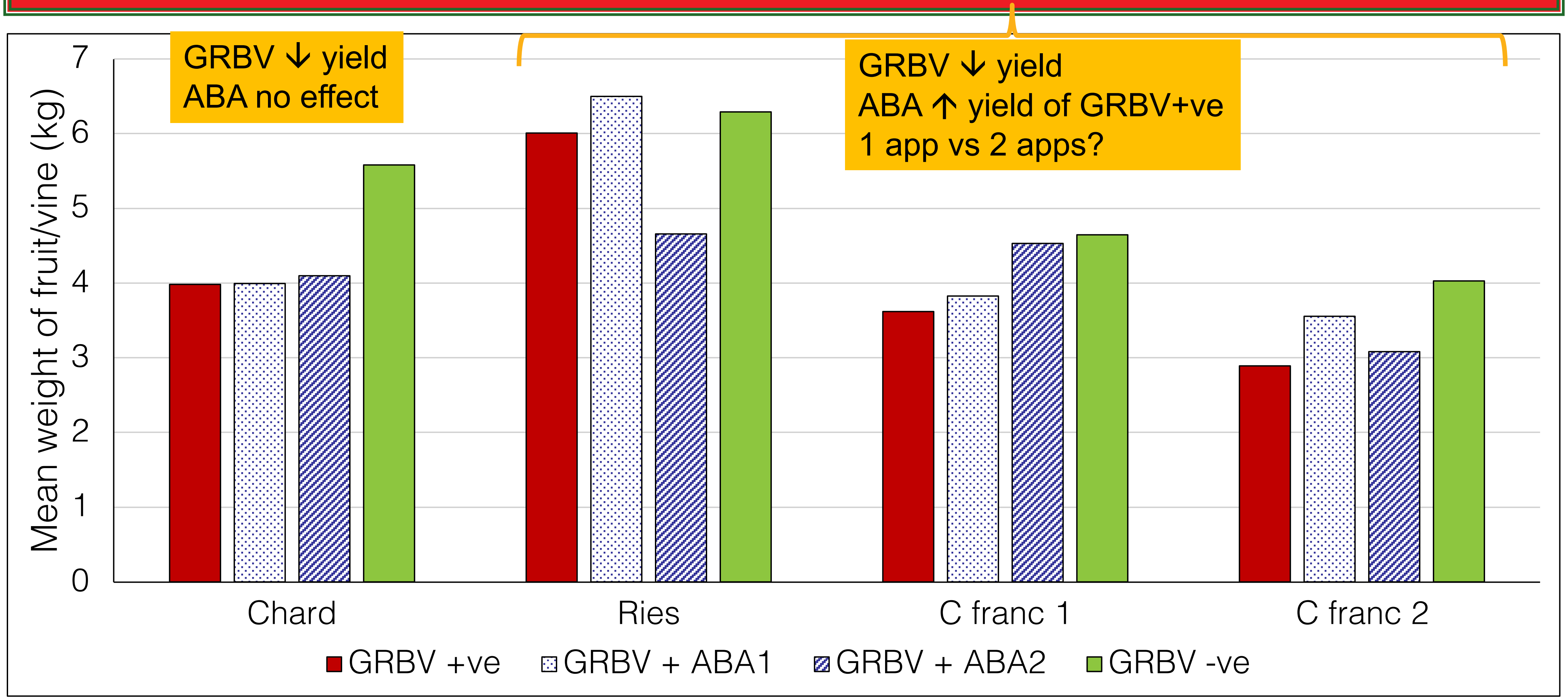
- Abscisic acid (ABA)
  - Linked to anthocyanin biosynthesis
  - Lower concentration in berries from GRBV +ve vines
  - GRBV may limit capacity of sources and sinks for exchanging reduced carbon and plant hormones simultaneously without shutting down the plant completely



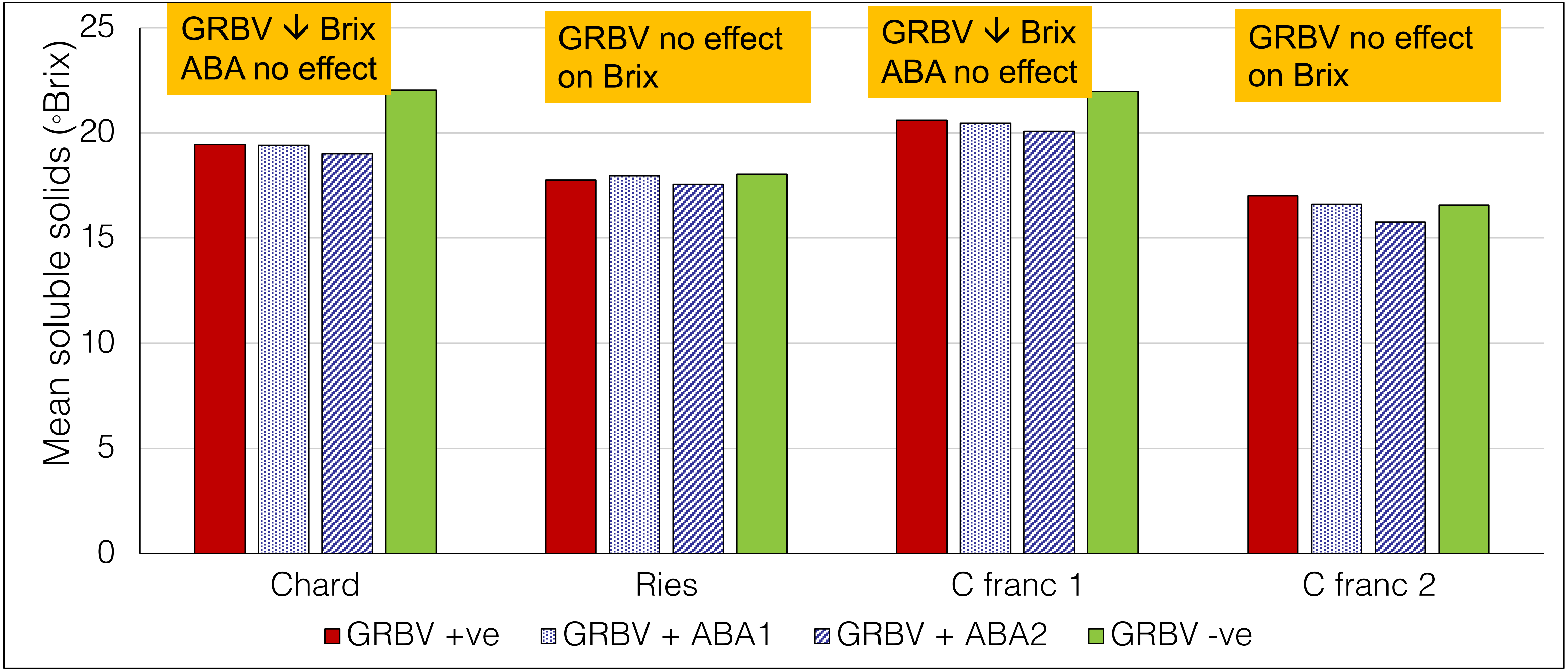
ABA to mitigate GRBV effects on Fruit Maturity

- 4 vineyards: 2 Cab franc, 1 Riesling, 1 Chard
- Vines identified with GRBV only (no GLRV)
- ABA (Protone) @ 400 ppm ABA
  - applied once or twice to full canopy
  - 50% veraison and 2 weeks later
- Fruit harvested at commercial ripeness

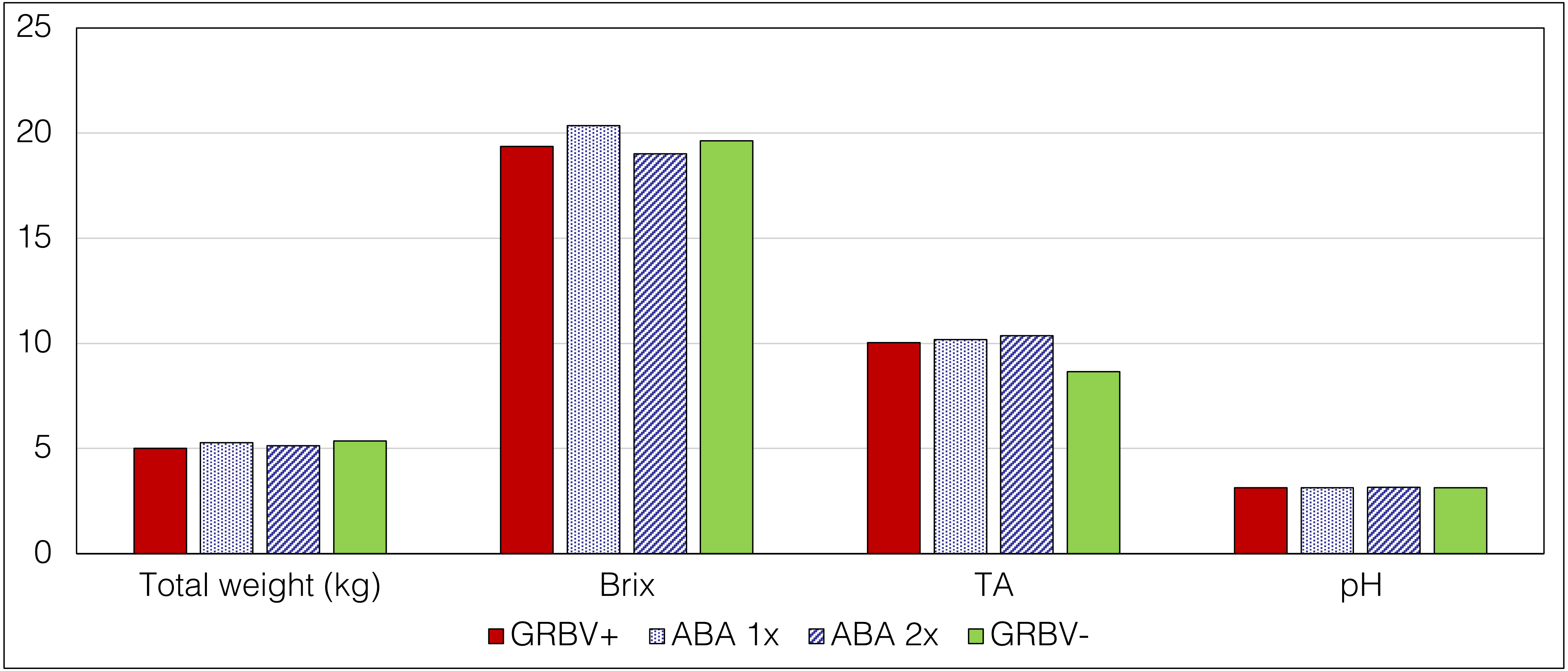
ABA to mitigate GRBV effects on Yield?



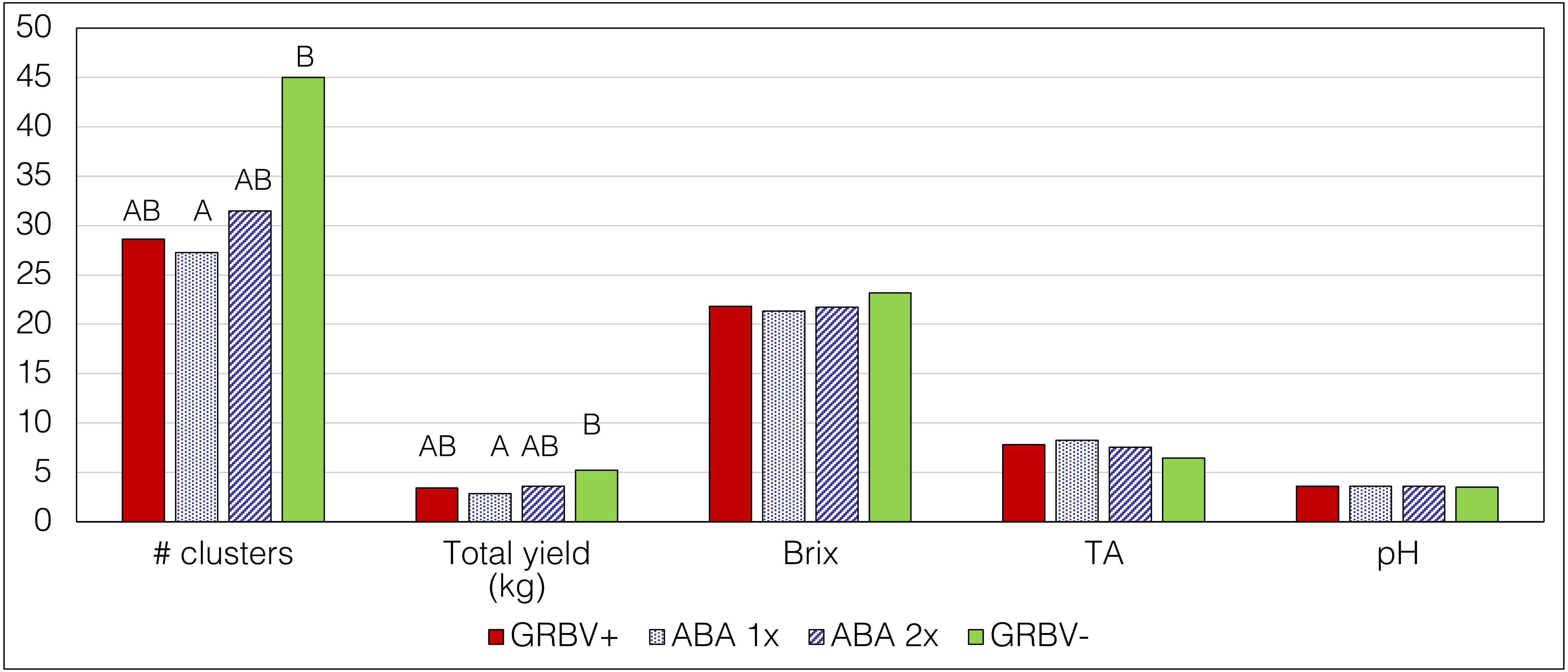
ABA to mitigate GRBV effects on Brix?



ABA on Riesling 2020

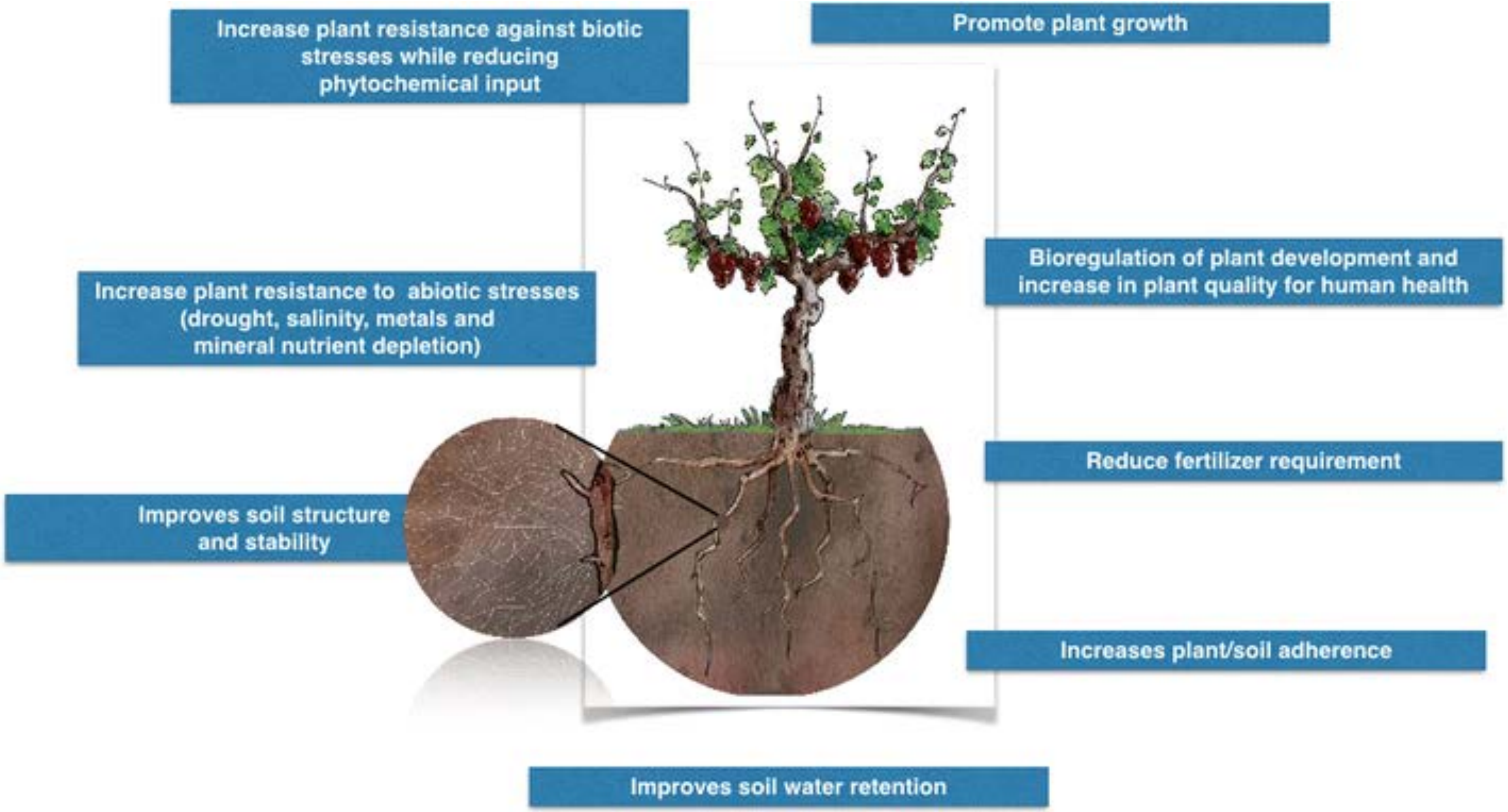


ABA on Chardonnay 2020

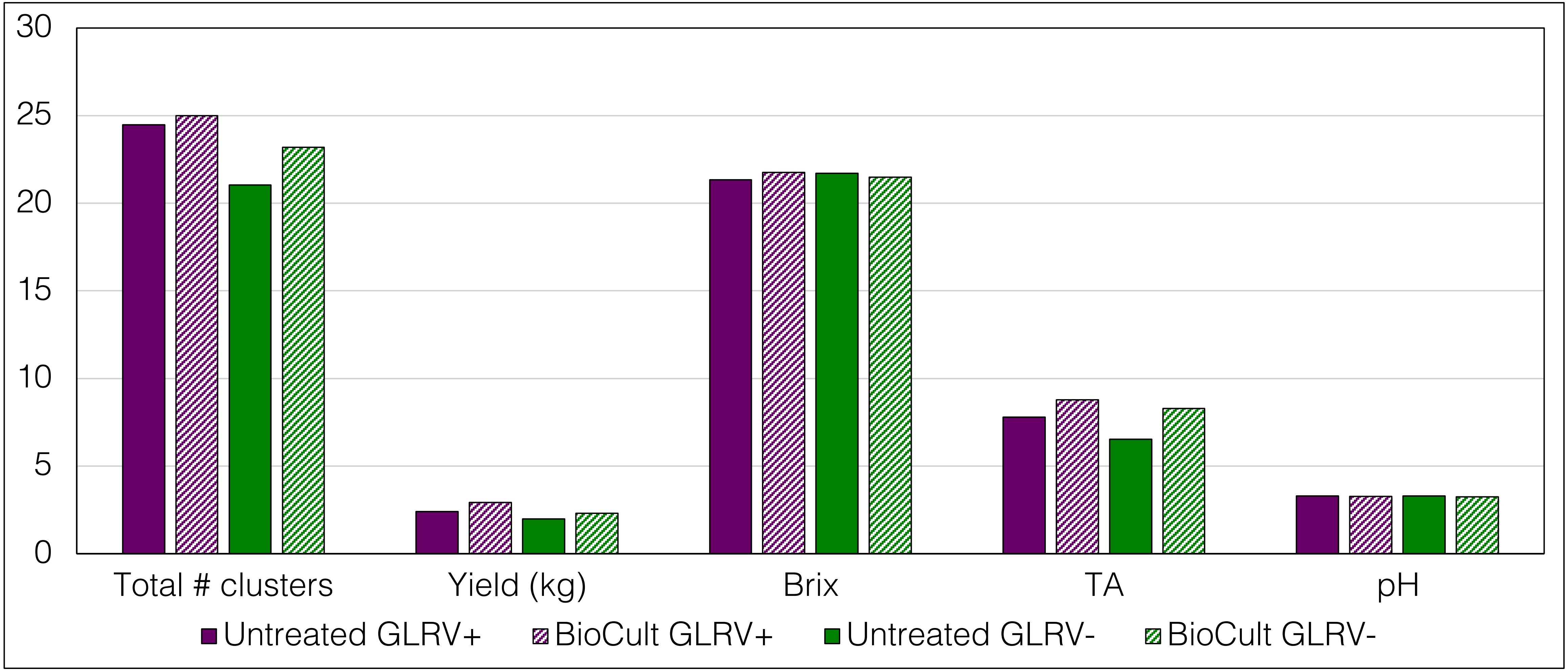


Mycorrhizae?

- 200g BioCult Mycorrhizae in 350L over 0.83 Acres



Mycorrhizal Treatment, Chardonnay, 2020



GRLaV and GRBV Transmission

- No mechanical transmission of GLRaV in vineyards
  - pruning, hedging, trimming, harvesting, suckering, etc
- No vine-to-vine transmission via root grafting

Insect Vectors of GLRaV

- Mealybugs and Soft Scales
  - grape mealybug, (*P. maritimus*), obscure mealybug (*P. viburni*) longtailed mealybug (*P. longispinus*) vine mealybu (*Planococcus ficus*)
- Soft scales
  - lecanium scale (*Parthenolecanium corni*

Insect Vectors of GLRaV

- Mealybugs
  - More efficient at transmitting GLRaV-3 than soft scales
  - Early instars more efficient than more mature stages
  - Virus is semi-persistent
  - Feeding by one viruliferous insect sufficient to cause infection
  - Acquire GLRaV within 24 hours of feeding on infected vines
  - Symptoms not until the following year

Which mealybug is in Ontario?

Representative samples collected into 95% EtOH

Analyzed by PCR

Confirmed grape mealybug (*Pseudococcus maritimus*)

Grape mealybug in Ontario. So what?

- 2 generations/year (overwintering and summer)
  - Other species 3-7 generations/year
- Does not infest roots
  - Other mealybugs do
- Pheromones are species specific
  - Monitoring, mating disruption

Grape Mealybug

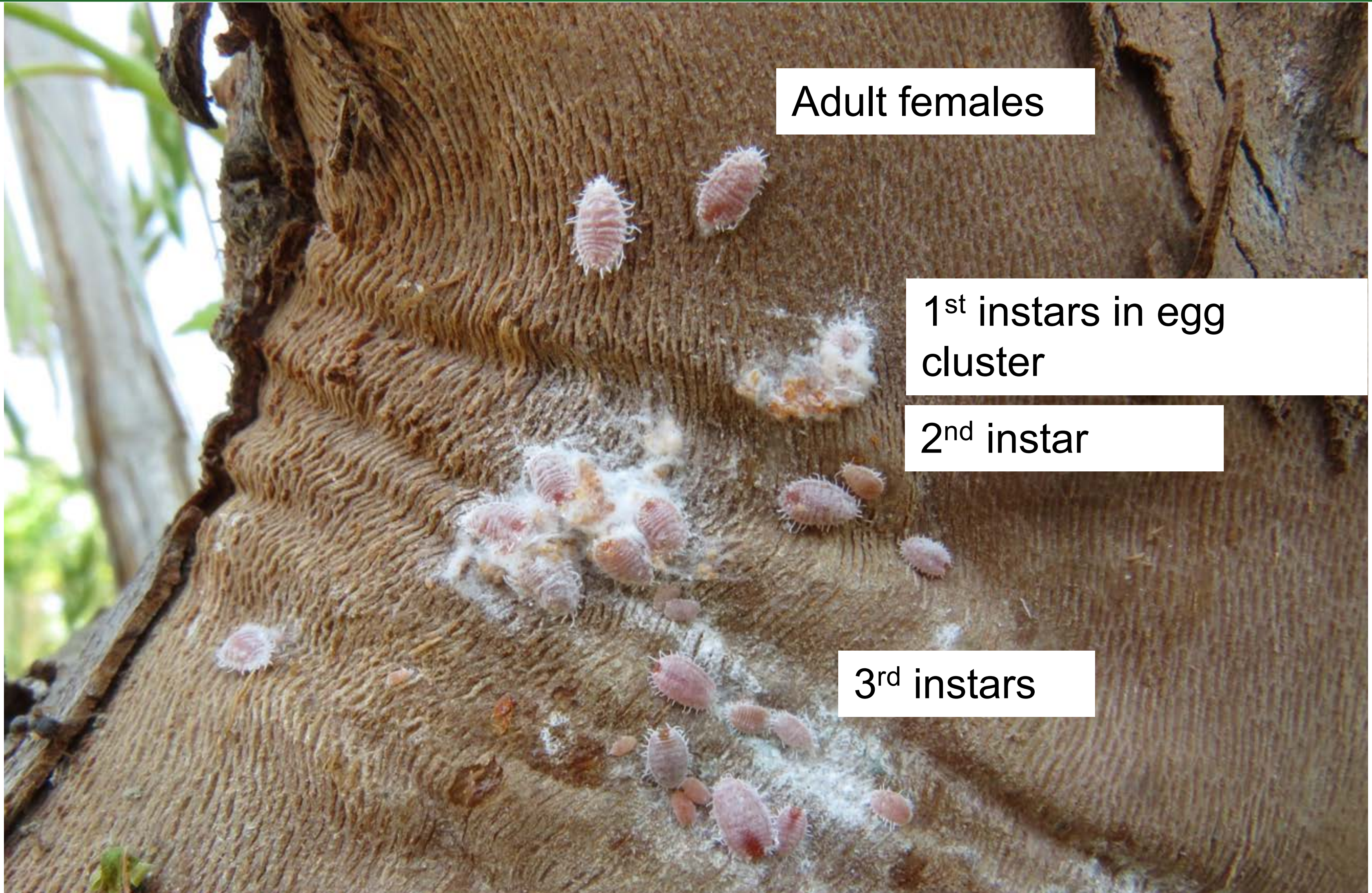
- 1st instar nymph
  - Most efficient vector stage
  - Most mobile stage
  - Walk vine to vine (1 m)
  - Wind (low proportion, up to 8 m) (Grasswitz & James, 2008)
  - Hitchhiker on workers, machinery?

Grape Mealybug Life Cycle

Overwinter as eggs and 1st instars

Grape Mealybug Life Cycle

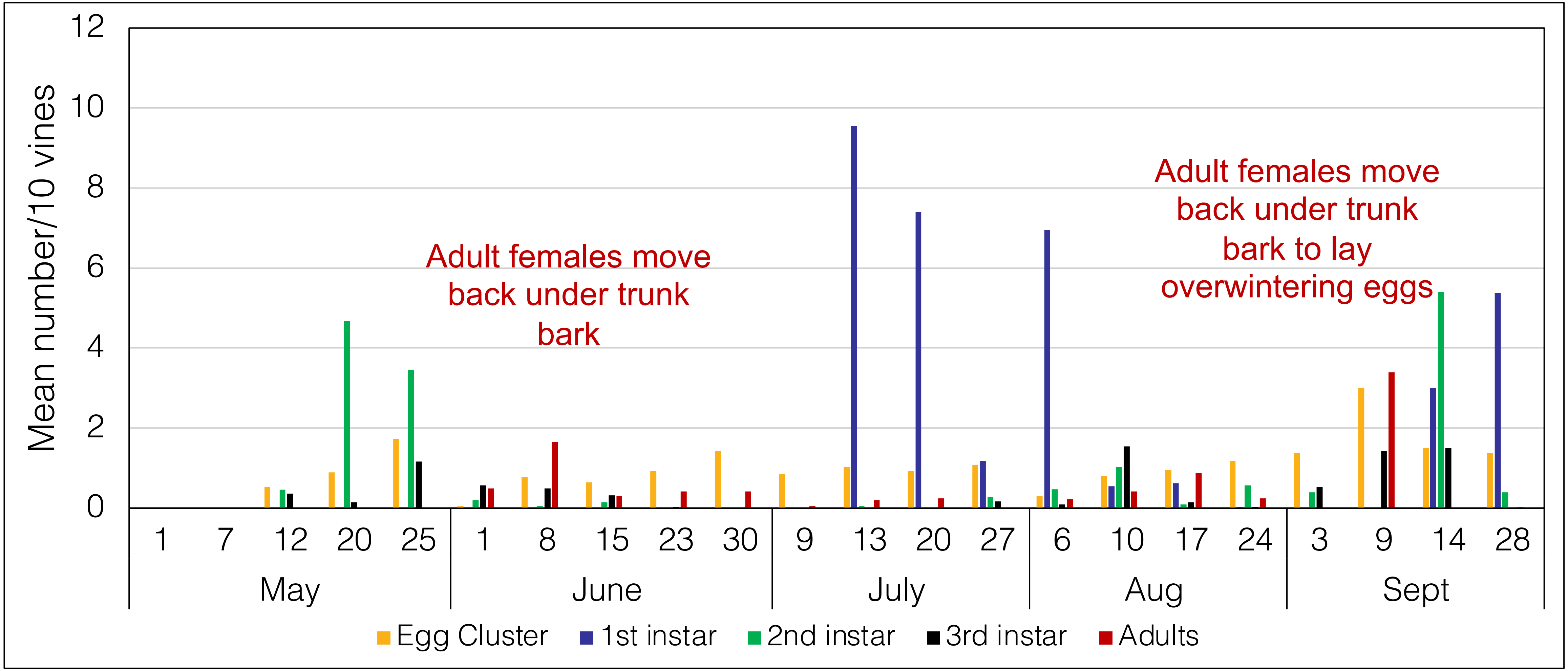
Grape Mealybug Life Cycle



Grape Mealybug Life Cycle

Emerge in spring and move onto canes to feed, hiding beneath bark

Grape Mealybug Life Cycle

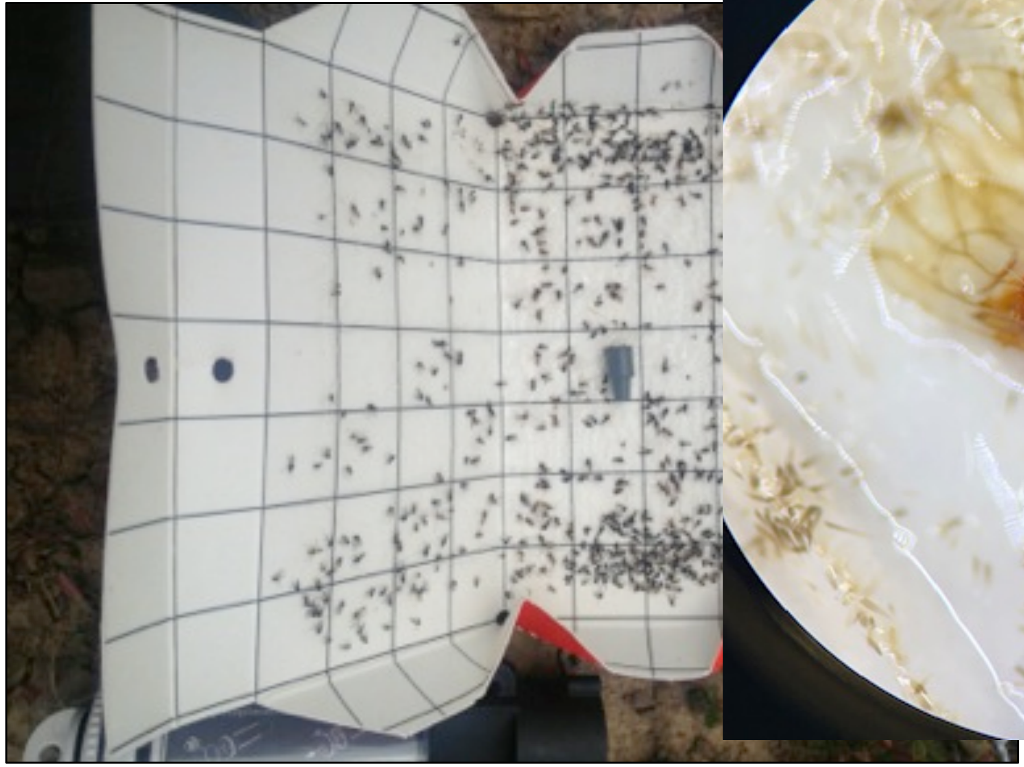


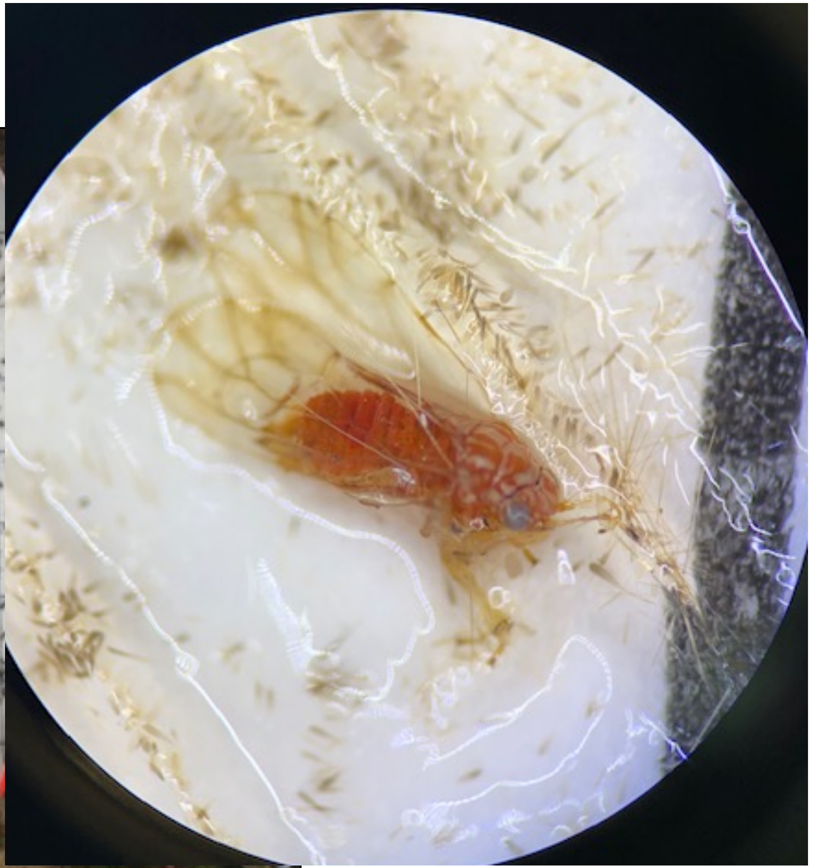
Monitoring for Grape Mealybug

Figure 6. Pheromone-baited trap placed in the vine canopy during the dormant (A) and mid-season (B).

Photo: D. Dalton, © Oregon State University

- Pheromone traps





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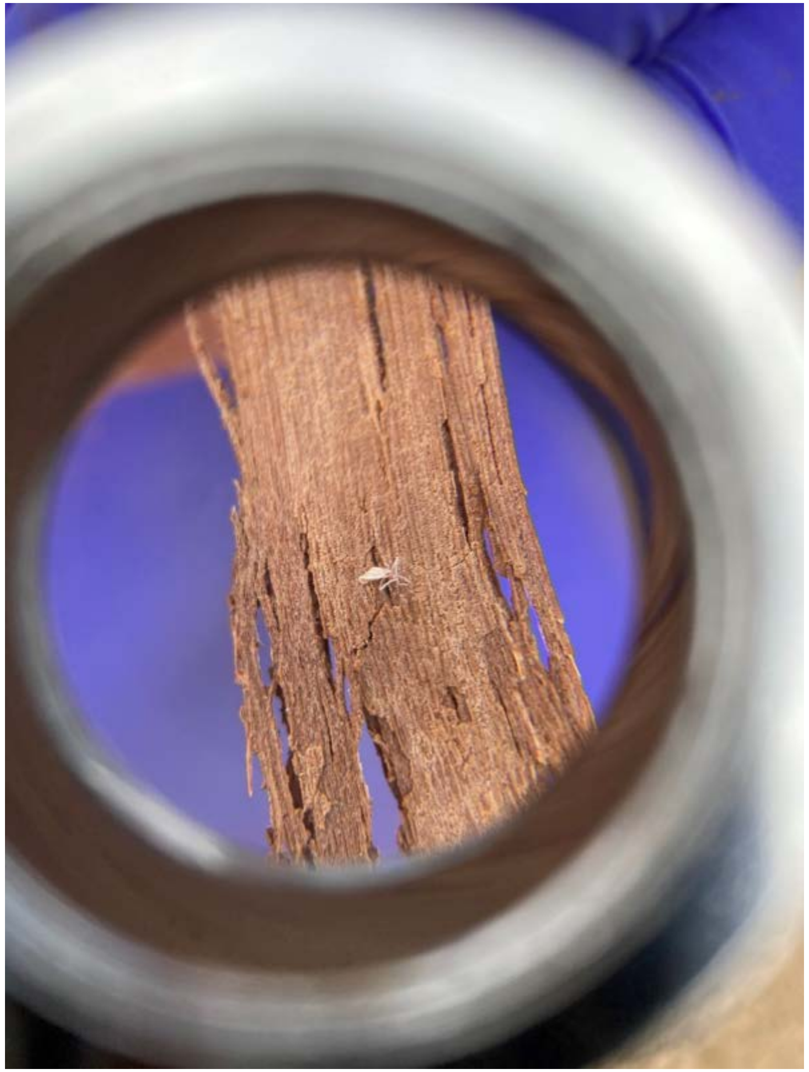

Monitoring GLRaV Vector Development

Monitoring GLRaV Vector Development

Grape Mealybug Management

- Oils, Insecticidal Soap, Clutch 50 WDG
  - Contact only
- Malathion 85E
  - Contact + volatile?
- Timing for overwintering generation?
  - Model to predict mealybug crawler emergence

Grape Mealybug Management

- Movento 240SC
  - Bi-directional movement in phloem
  - Movement under bark where mealybugs are feed requires translocation
  - Leaves don't export a lot of sugars before there are at least 5 leaves present
  - Full label rate – 460 mL/ha 2X
  - Timing – post bloom, 30 days later

Grape Mealybug Management

- Bee aware of pollinators!
  - Avoid spraying these insecticides if cover crops or weeds in row middles are in bloom
  - Minimize off-target drift

Future Endeavours

Biological control?

- Modified insecticide sprays
- Cover crops
- Introductions
- Challenge – majority of GMB and Scale are under bark so difficult for beneficials to find them

Future Endeavours

- Manage ant populations to manage vectors?

Control ants – reduce mealybugs

Written by Mary Shanahan

font size | Print | Email

A student research project has produced promising results for an indirect approach to reducing mealybug infestations in vineyards.

The project says this can be done by controlling the ants that protect and milk the insects for their honeydew.

Catherine Hardiman, who undertook her study during

How do I know if mealybugs or scales are in my vineyard?

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Good Fruit Grower

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Hoppers at heart of red blotch

Confirmation of red blotch-associated virus vector means more studies are ahead.

‹ NW … rieties ›

Shann … search

Three-cornered alfalfa hopper damage

Spissistilus festinus

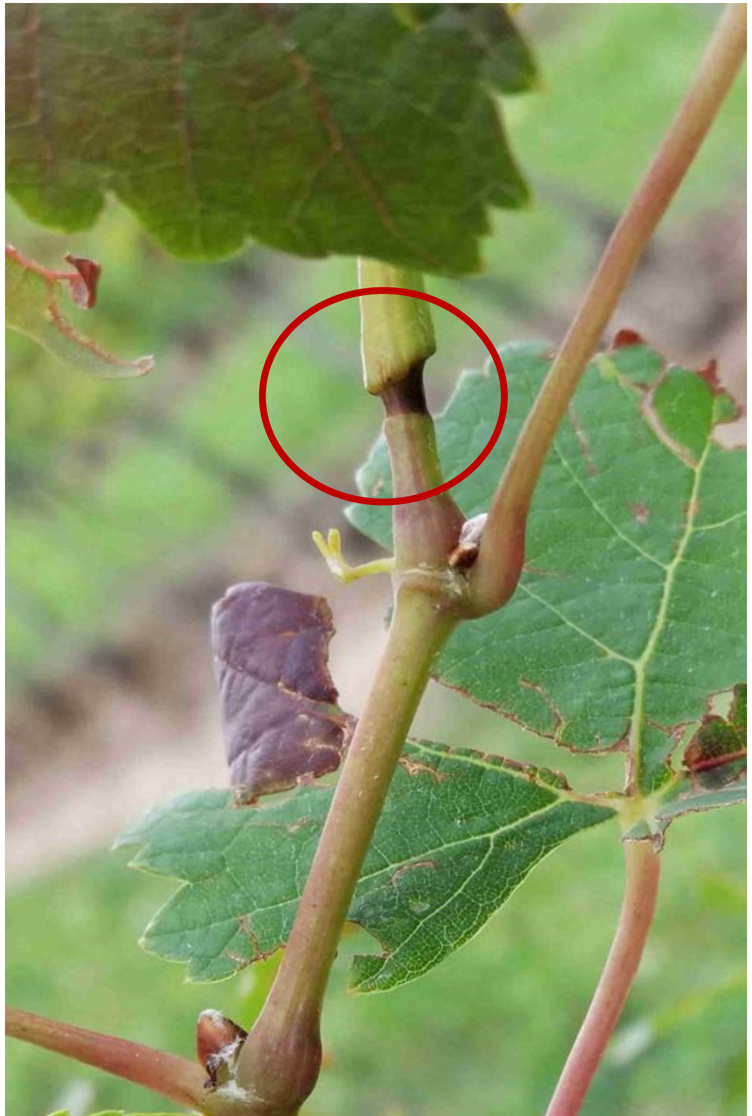
Leaf girdling

Red leaf

Hunting for vineyard disease vectors

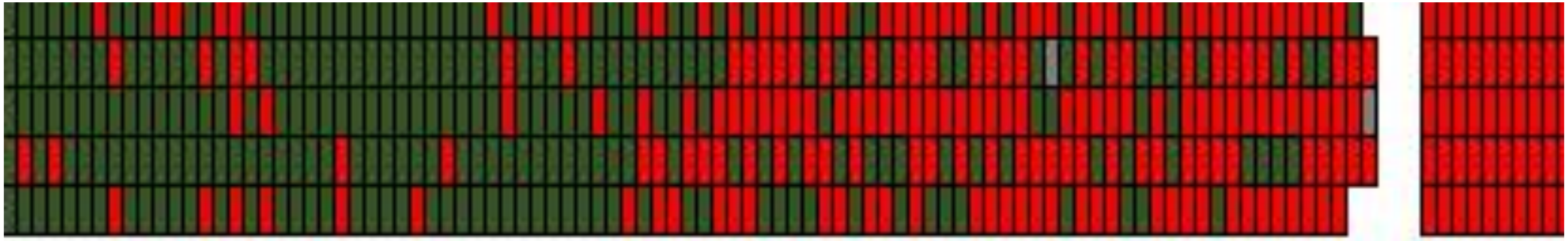
Buffalo treehopper emerges as a potential carrier of virus that causes red blotch disease.

Reported Vectors of GRBV



Buffalo Treehopper
Vector of GRBV

Does Red Blotch Spread?



Variety B

Variety A

GRBV +ve

GRBV -ve

Does Red Blotch Spread?

Experiment Using Sentinel Vines

June

Healthy virus-free potted vines

July – Nov.

Placed in the vineyard with GRBV infection

Nov.

Removed all leaves and sprayed with pesticide before placing the vines in the greenhouse

Feb.

Tested for GRBV 3 month post re-growth

1) Which insects can ***acquire*** GRBV?

Cieniewicz et. al 2018 & 2019 – DNA testing of vineyard-captured insects
2018 California
2019 California & 2019 New York

Colladonus reductus

40%
25%

Osbornellus borealis

40%
71%

Spissistilus festinus

50%
40%

Melanolarius
.

70%
0/1

Scaphytopius

8%
19%

Scaphoideus sp. 19%

Empoasca sp. 12%

Cicadula sp. 11%

Buffalo treehopper 0/3

1) Which insects can ***acquire*** GRBV?

In Niagara region: 10 vineyards sampled July-September 2019

Six locations / vineyard

Three yellow sticky cards / location

Cards checked and replaced weekly

Osbornellus borealis

6

Scaphoideus titanus

Vine Leafhopper

126

Stictocephala sp.

Buffalo treehopper

4

Melanolarius sp.

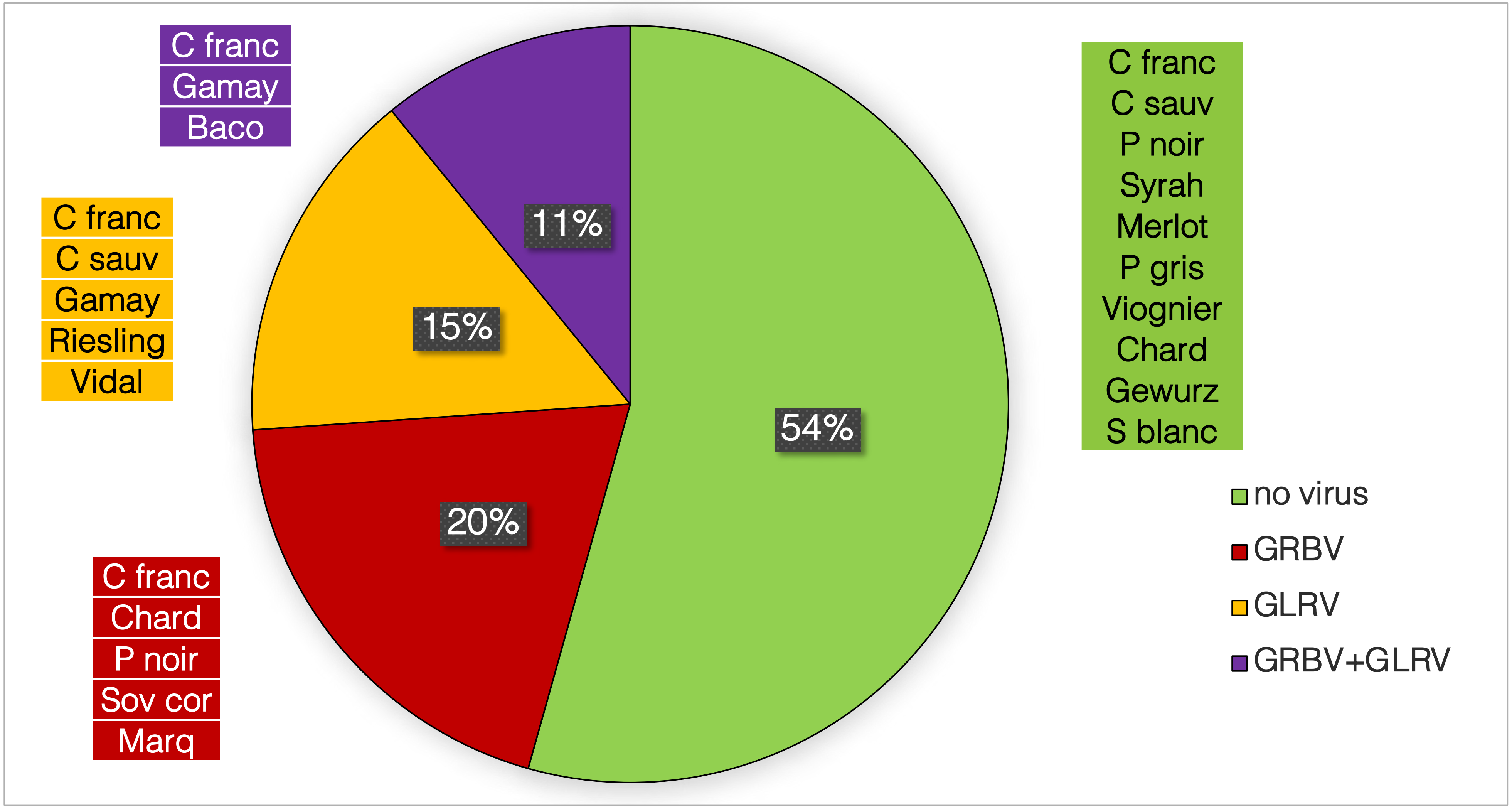
19

Species Name	Total No. collected
Agallia constricta	53
Ancanalonia conica	2
Aphrodes sp.	1
Chlorotettix sp.	1
Clastoptera proteus	2
Delphacidae sp.	1
Dracucephala antica	1
Draculacephala minerva	3
Echenopa binotata	1
Erythroneura sp.	914
Euscelidius variegatus	5
Forcupata sp.	1
Graminella nigrifons	39
Graphocephala coccinea (Red-ban	101
Gyponana salsa	43
Jikradia olitoria	88
Lygus Spp.	22
Metcalfa pruinosa	1
Macrosteles laevis	1
Macrosteles quadrilineatus	30
Melanoliarus aridus	19
Micrutalis calva (Honeylocust Tre	102
Norvellina sp.	1
Orientus ishidae	2
Osbornellus borealius	6
Paraphlephsius irroratus	34
Philaenes spumroris	7
Empoasca fabae (Potato Leafhop	8281
psyllidae sp.	1
Stictocephala alta (Buffalo Treeho	4
Scaphoideus immistus	1
Scaphoideus titanus	126
Scaphytopius acutus	4
Spilaenus spumarcus	1
Stink bug	1
X superbus	19
Total	**10,032**

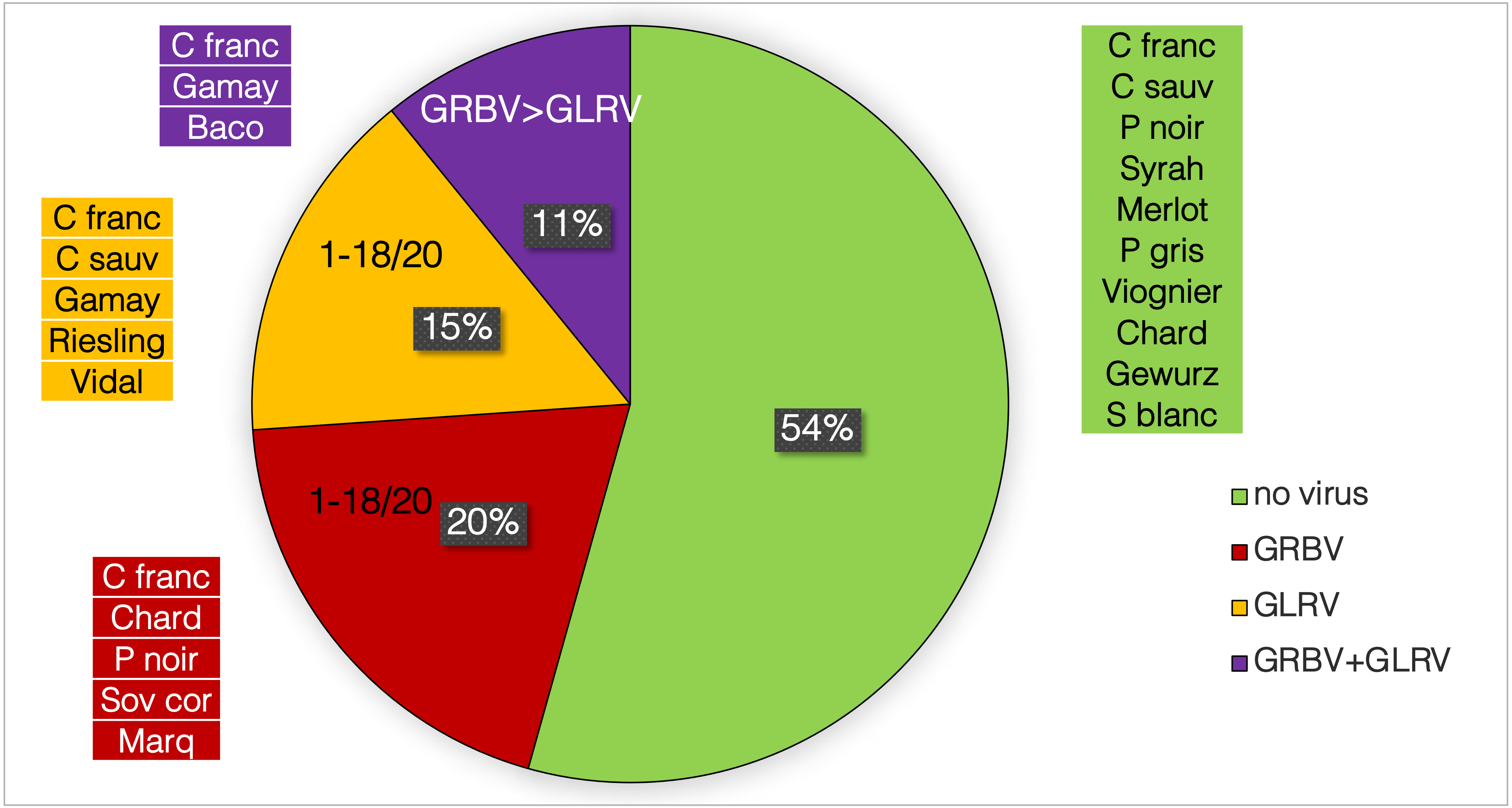
GRLaV and GRBV Transmission

- Propagation of infected (symptomless) vines

2020 Survey, Vines planted 2018-2020



2020 Survey, Vines planted 2018-2020



Management of Virus Diseases

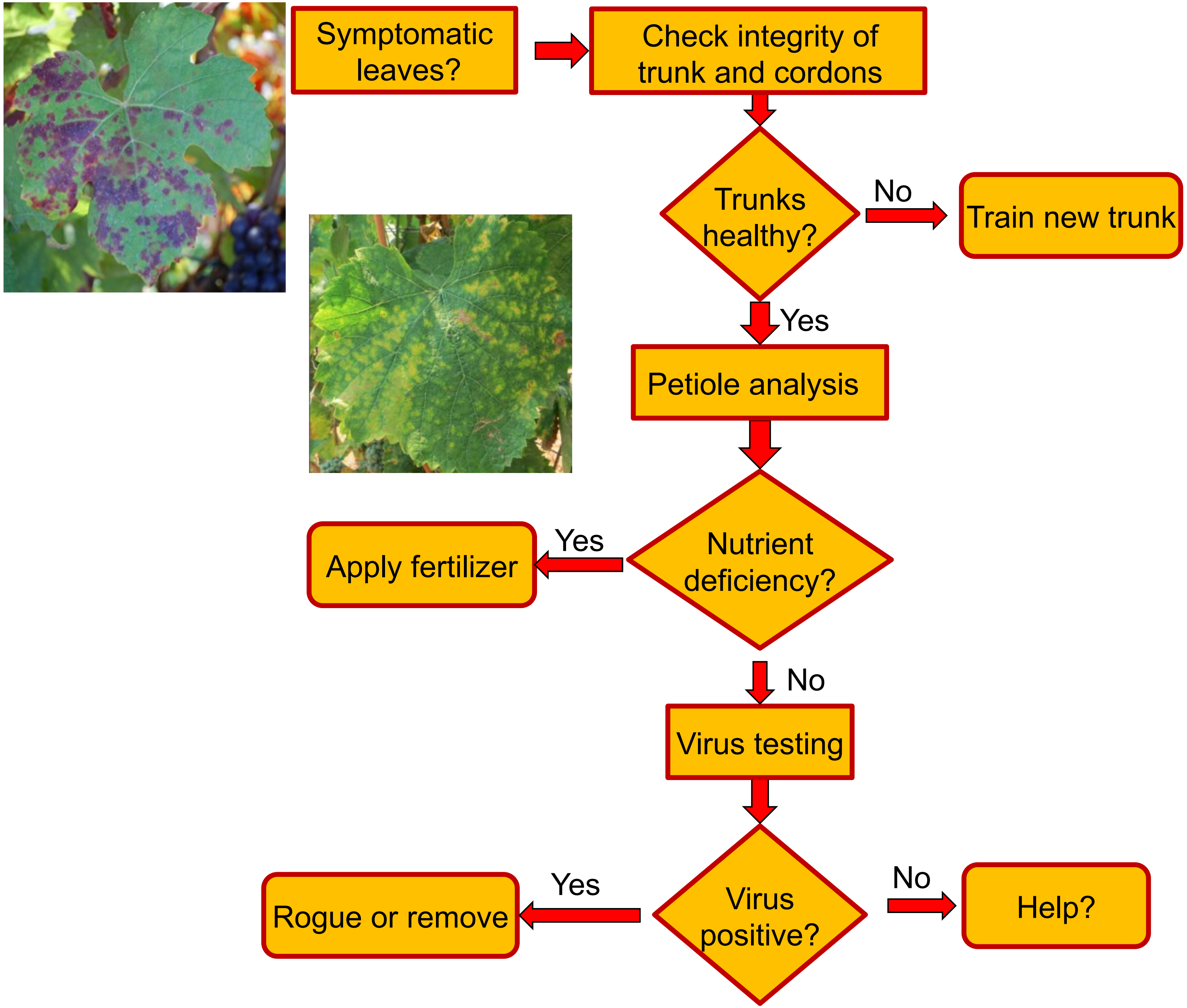
- Demand virus-free nursery material
  - Scion and rootstock

https://www.youtube.com/watch?v=jLzVCjtBPNA&feature=youtu.be

Management of Virus Diseases

- Demand virus-free nursery material
  - Scion and **rootstock**
- Remove infected vines (up to 25-30% infected)
  - Mark symptomatic vines during the growing season
  - 1+2 approach (Dr. Vaughn Bell) (https://www.youtube.com/watch?v=HmUnEUIShK4&feature=youtu.be)
- Manage vine stress (water, crop load, fertility)
- Remove infected blocks (30%+ infected)
- Manage insect vectors

If you see red leaves….


Symptomatic leaves?
Check integrity of trunk and cordons
Trunks healthy?
No
Train new trunk
Yes
Petiole analysis
Nutrient deficiency?
Yes
Apply fertilizer
No
Virus testing
Virus positive?
Yes
Rogue or remove
No
Help?

Questions?

wendy.mcfadden-smith@ontario.ca