Managing Vine Nutrition for the Winery

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Vineyard Soil Technologies. Inc

Outline

1. Soil and Vine Potassium and its impact on juice pH
   A. Soil and vine potassium uptake
   B. Impact on juice pH
   C. Treatment options

2. Yeast Assimilable Nitrogen (YAN)
   A. Soil and vine nitrogen status
   B. Impact on juice fermentations
   C. Treatment options

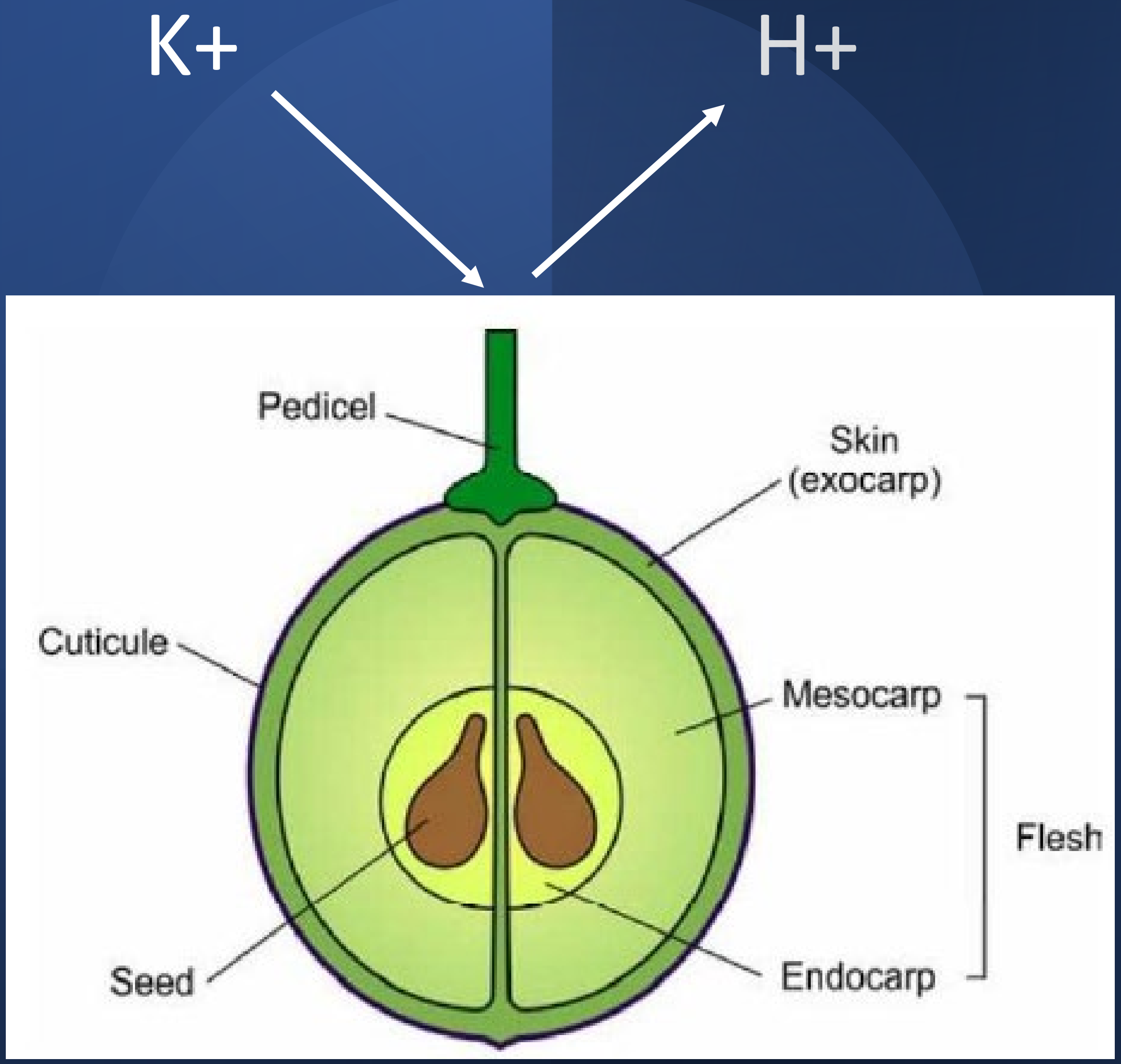
3. Excessive Heat on the Berries
   A. How hot is hot
   B. Impact on the berries
   C. Treatment options

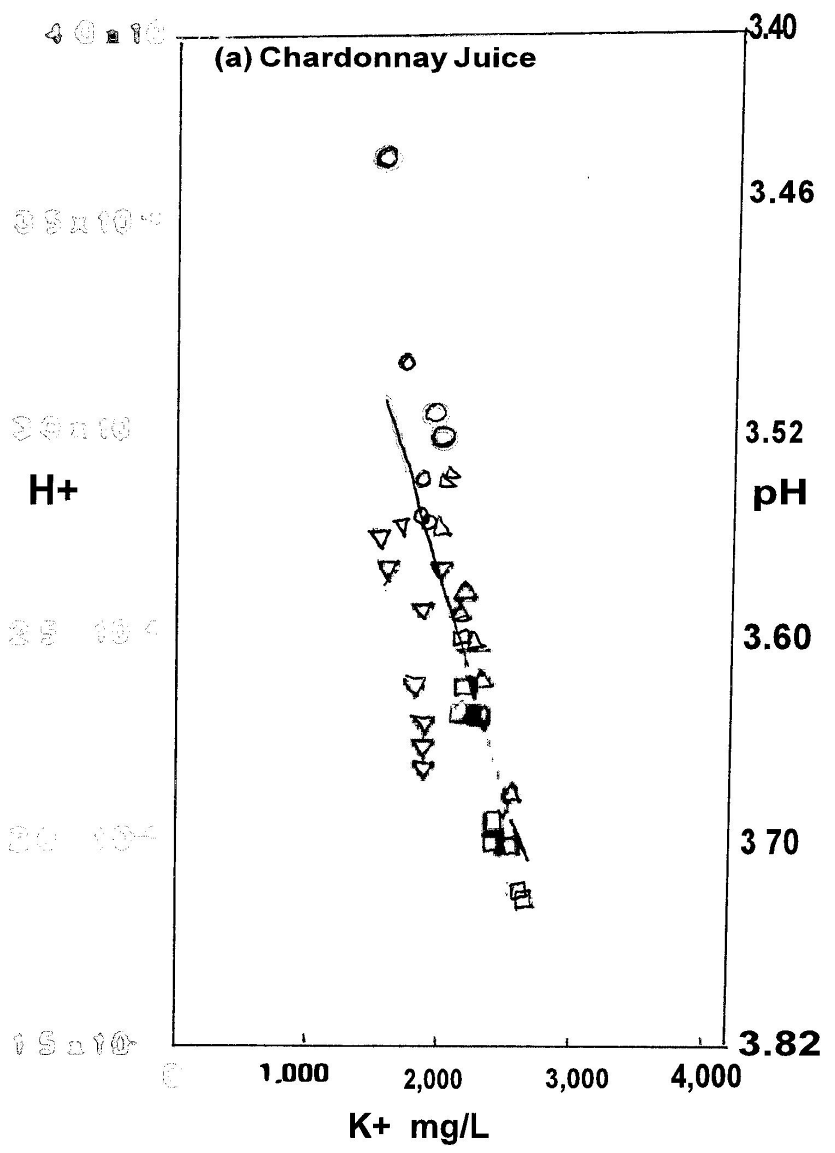
The potassium uptake and berry juice pH conundrum

1. **Excessive soil potassium uptake into the vine may cause excessively high berry juice pH (> 3.8)**
2. **High berry juice pH values cause microbial stability issues in the finished wine.**
3. **High berry juice pH values may precipitate potassium tartrate.**

As the potassium (K^+) is imported into the berry, the charge imbalance is handled by exporting H^+.

This results in less H^+ in the berry and increases the juice pH in the berry.





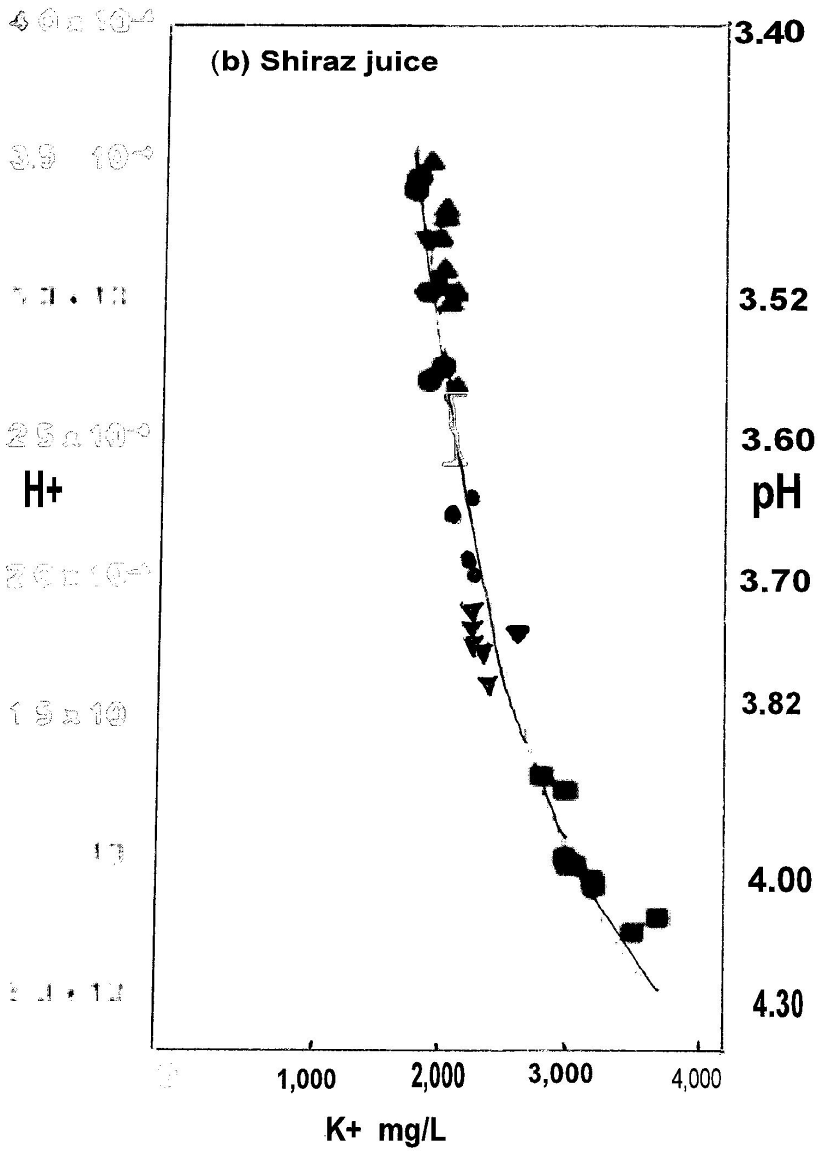


Figure 1. Regression of grape juice H+ (mmol/L) on grape juice K+ (a,b) and of wine H+ on wine K+ (c,d) for Chardonnay (left, open symbols) and Shiraz (right, closed symbols). Grape juice data are means for seasons 1996 and 1997.).

Potassium concentration and pH inter-relationships in grape juice and wine of Chardonnay and Shiraz from a range of rootstocks in different environments.

R.R. WALKER and D.H. BLACKMORE
Australian Journal of Grape and Wine Research 18, 183–193, 2012Australian Journal of Grape and Wine Research 18, 183–193, 2012

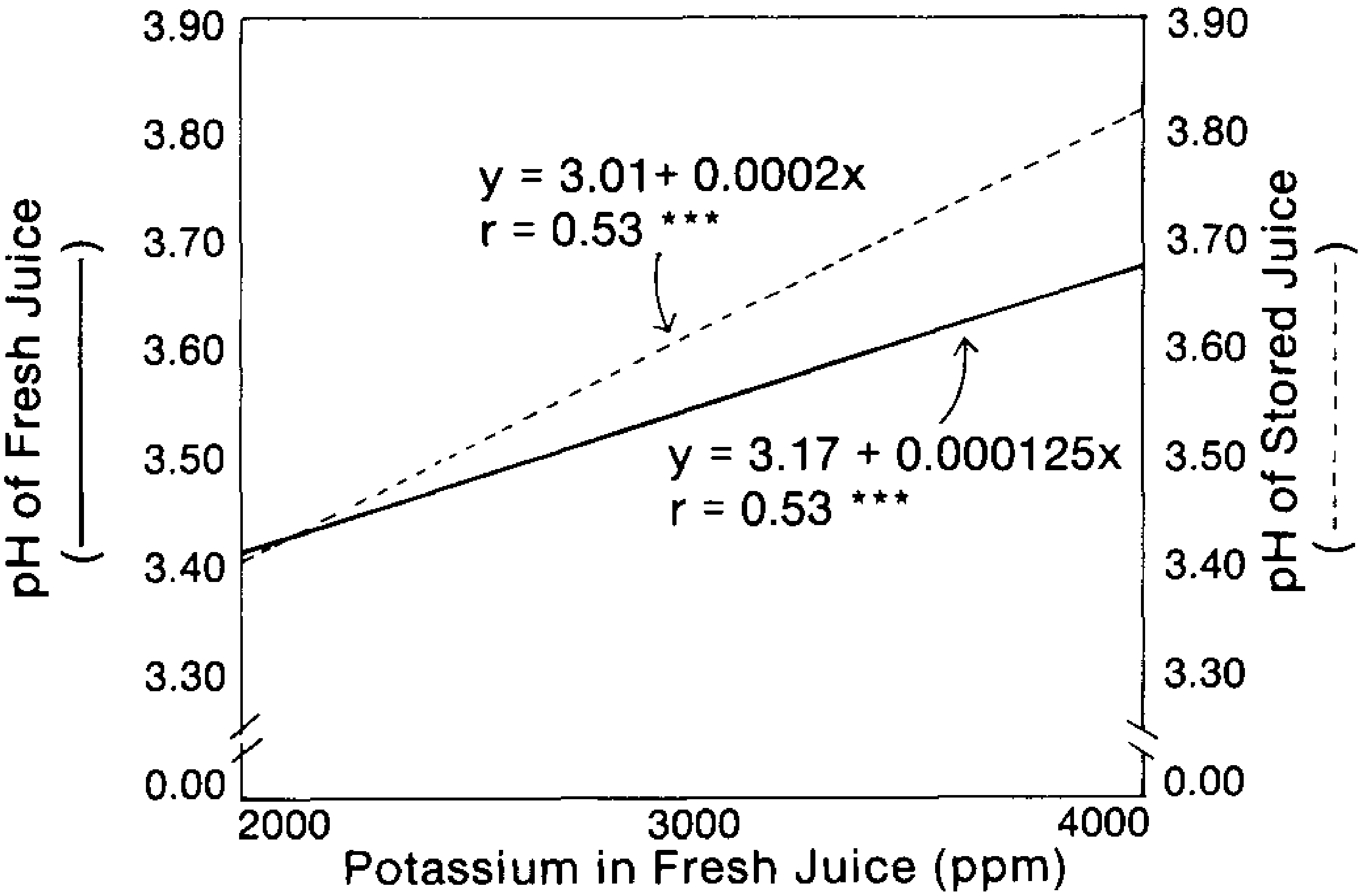


Fig. 1 Relationship between potassium in the fresh juice and the pH of the fresh and stored juice.

J. R. MORRIS, 1 C. A. SIMS, 2AND D. L. CAWTHON, Effects of Excessive Potassium Levels On pH, Acidity and Color of Fresh and Stored Grape Juice. Am. J. Enol. Vit., Vol. 34, No. 1, 1983

Acidity management is one of the most important considerations for wine quality, especially for wine stability. Some of the significant stability concerns related to pH are:

- **Inhibition of spoilage organisms at low pH**
- **Lower pH favors molecular sulfur dioxide (SO2), the anti-microbial form**
- **More red color at low pH, going to ‘blue’ as pH increases**
- **Oxidation rates decrease as pH decreases.**

Fahey, D. and Scollary, G. 2020. Managing acidity in grapevines and wines. New South Wales. ISBN 978-1-76058-290-6 (Online)

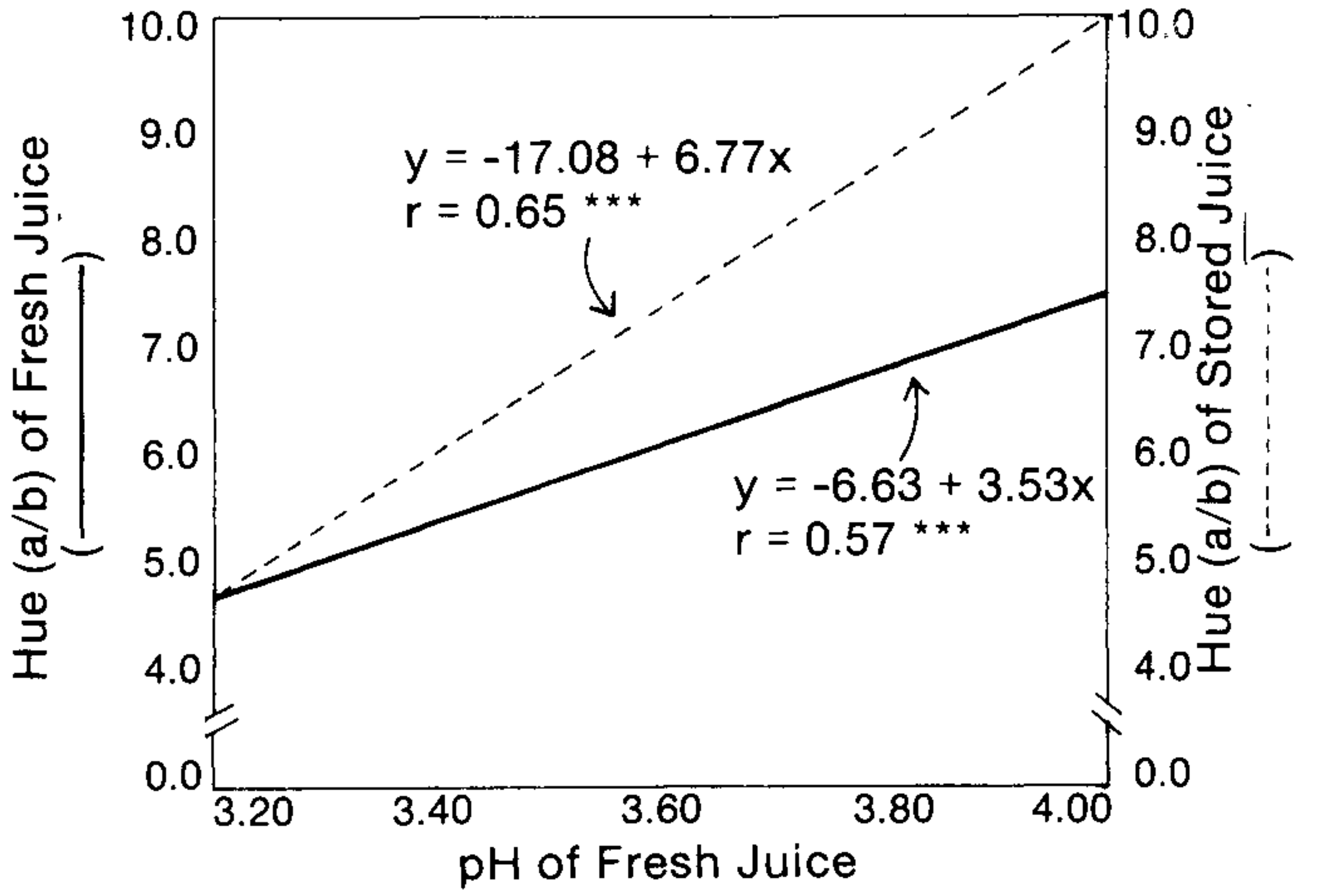


Fig. 2. Relationship between pH of the fresh juice and the hue of the fresh and stored juice.

J. R. MORRIS, 1 C. A. SIMS, 2AND D. L. CAWTHON, Effects of Excessive Potassium Levels On pH, Acidity and Color of Fresh and Stored Grape Juice. Am. J. Enol. Vit., Vol. 34, No. 1, 1983

High color hue indicates a bluer or browner, less bright color (Somers 1975), and the positive relationship between wine color hue and wine pH agrees with previous observations that high wine pH is linked to lower wine stability, poorer color and overall, poorer quality (Somers 1975, Boulton 1980b)

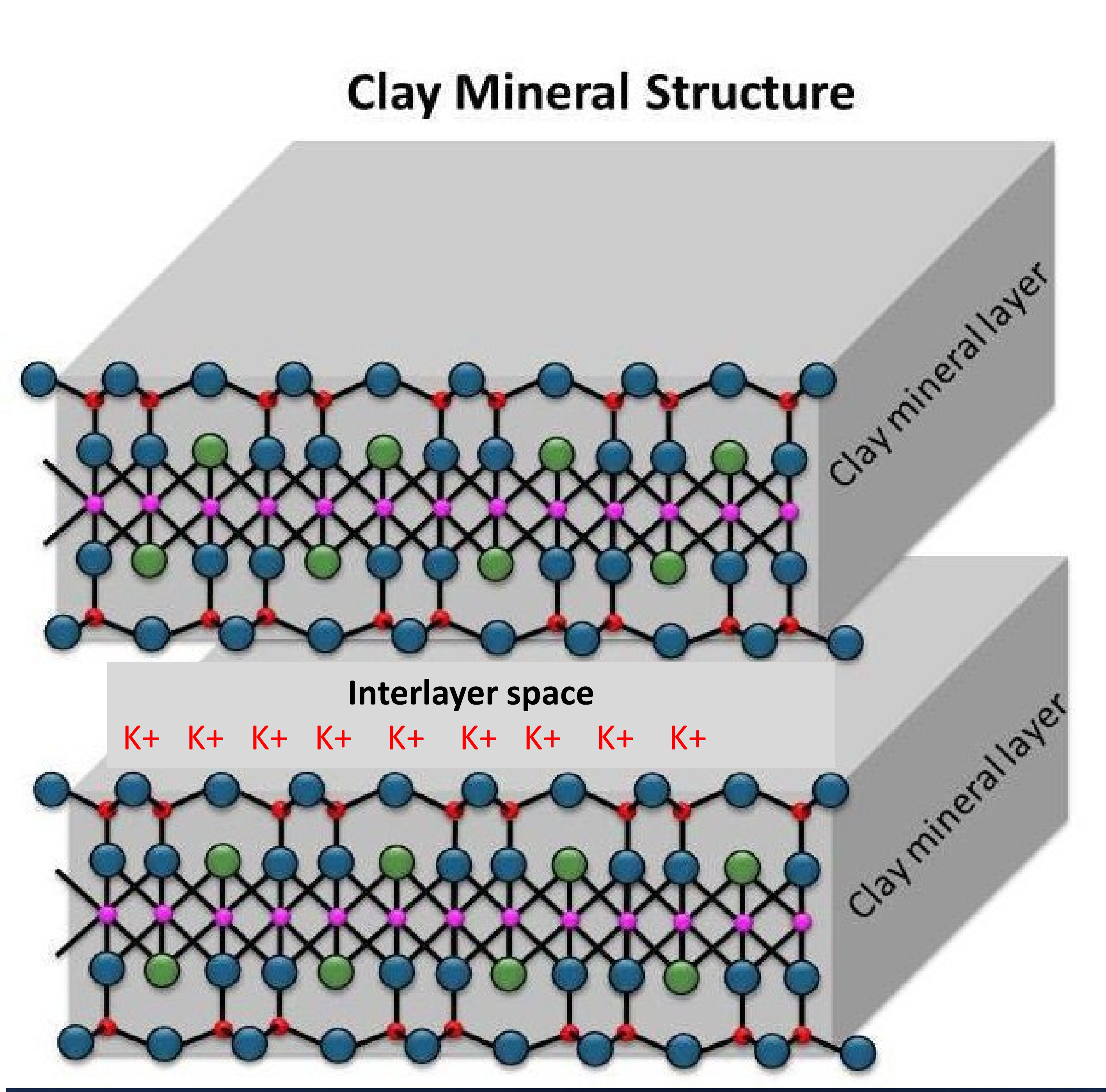
Walker and Blackmore-2012. Potassium concentration and pH inter-relationships in grape juice and wine of Chardonnay and Shiraz from a range of rootstocks in different environments. Australian Journal of Grape and Wine Research 18, 183–193, 2012

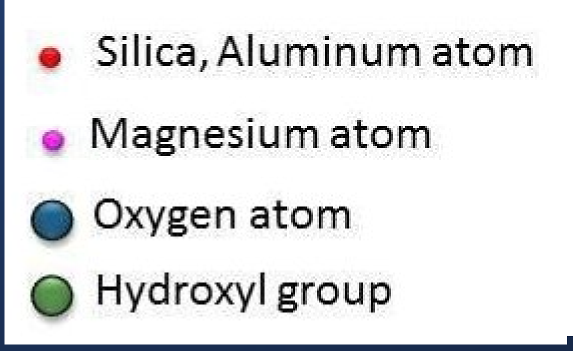
How does this happen? What causes excessive K^+ ?

1. **Alumino-Silicate clays derived from high-Potassium parent material, especially volcanics (rhyolite, andesite, breccia).**

   Upon wetting the interlayer space expands letting water and soluble potassium into or out of the space depending on the soil solution equilibrium.

   So, soils with high potassium will constantly exude potassium from the interlayer space.





How does this happen?
What causes excessive K^+ ?

2. **Excessive application of potassium fertilizers.**

3. **Excessive applications of high-potassium compost, especially grape pomace.**

Adding tartaric acid to the wine has been the traditional way to adjust acidity. It is relatively easy to do and the amount to be added can be determined by bench tests or using web-based calculators. There are, however, some limitations with this method including:

- the procedure can be expensive as quality L(+) tartaric acid is costly
- the amount required to attain the desired pH decrease can be large
- losses of the added tartaric acid, via precipitation of potassium hydrogen tartrate (KHT), can be excessive, meaning further tartaric acid additions
- high juice potassium concentrations will exacerbate these losses
- some countries have limits on the amount that can be added.

§ 24.246 Materials authorized for the treatment of wine and juice.

The TTB published Materials Authorized for Treatment of Wine and Juice has 70 approved chemicals. But only weak acids to counter pH values.

Notice absence of strong acid:

HNO_3 Nitric Acid
HCl Hydrochloric Acid
H_2SO_4 Sulfuric Acid

TABLE 1 TO PARAGRAPH (c)—MATERIALS AUTHORIZED FOR TREATMENT OF WINE AND JUICE

Materials and use	Specific TTB limitation (if applicable)	FDA reference
Acacia (gum arabic): To clarify and stabilize[1] wine	The amount used must not exceed 16 pounds per 1,000 gallons (1.9 g/L) of wine	21 CFR 184.1330.
Acetaldehyde: For c concentration		
Activated carbon:		
To assist pr		

[1] To stabilize—To pr

[2] Parts per million—

[3] Parts per billion—

[4] An effective food c the manufacturer/s

Materials and use	Specific TTB limitation (if applicable)	FDA reference
To clarify and purify wine	The amount used to clarify and purify wine must be included in the total amount of activated carbon used to remove excessive color from wine and/or juice. 27 CFR 24.241 and 24.242	FDA advisory opinion dated January 26, 1979, which states that the activated carbon must meet the specifications in the Food Chemicals Codex and be removed from the wine.
To remove color from which wine is produ		
Albumen (egg white): Fining a		
Alumino-silicates (hydrated) e clay) and Kaolin: To clarify an		

[1] To stabilize—To prevent or to

[2] Parts per million—1 ppm = 0.

[3] Parts per billion—1ppb = 0.00

[4] An effective food contact no the manufacturer/supplier list

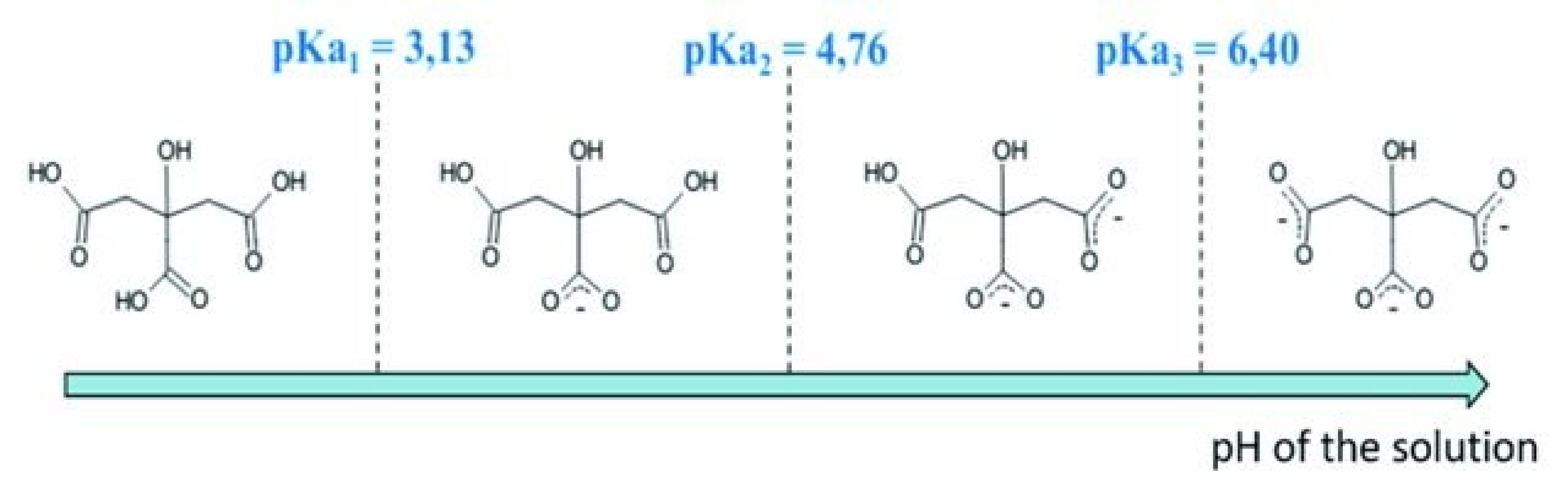
Materials and use	Specific TTB limitation (if applicable)	FDA reference
Ascorbic acid *iso*-ascorbic acid (erythorbic acid): To prevent oxidation of color and flavor components of juice or wine	May be added to grapes, other fruit (including berries), and other primary wine making materials, or to the juice of such materials, or to the wine, within limitations which do not alter the class or type of the wine	21 CFR 182.3013 and 182.3041.
Bakers yeast mannoprotein: To stabilize[1] wine from the precipitation of potassium bitartrate crystals	The amount used must not exceed 3.3 pounds per 1000 gallons (400 mg/L) of wine	GRAS (generally recognized as safe) Notice No. GRN 000284.
Calcium carbonate ($CaCO_3$) (with or without calcium salts of tartaric and malic acids):		
To reduce the excess natural acids in high acid wine, or in juice prior to or during fermentation	The natural or fixed acids must not be reduced below 40 pounds per 1000 gallons (4.79 g/L)	21 CFR 184.1069, 184.1099, and 184.1191.
As a fining agent for cold stabilization	The amount used must not exceed 30 pounds per 1000 gallons (3.59 g/L) of wine.	
Calcium sulfate (gypsum): To lower pH in sherry wine	The sulfate content of the finished wine must not exceed 1.67 pounds per 1000 gallons (0.2 g/L), expressed as potassium sulfate. 27 CFR 24.214	21 CFR 184.1230.
Carbon dioxide (including food grade dry ice): To stabilize[1] and preserve wine	See 27 CFR 24.245	21 CFR 184.1240.

Contributions to Acidity in Wine	
Acid (# carboxyls)	pKa
Tartaric-2	2.98 & 4.32
Malic-2	3.40 & 5.11
Citric-3	3.1 & 4.7 & 6.4
Lactic-1	3.86

Tartaric acid has an extremely tart, acidic taste.

Malic acid has a smooth, tart taste that lingers in the mouth without imparting a burst of flavor.

Citric acid has a tart sour taste.



Winery management of high pH juice values

Acidity adjustment – alternative strategies to adding just Tartaric acid

1. **Blending with higher acidity wines**
2. **Adding malic acid, which can be added as L or DL forms. This process is similar to adding tartaric acid except that malic acid is a weaker acid, so a higher rate will be required. The consequence is an increase in TA value and problems with microbiological stability.**
3. **Plastering – adding calcium sulfate $CaSO_4$**

$$CaSO_4 + H_2\text{-Tartrate} \longrightarrow \text{CaTartrate} + 2H^+ + SO_4^{2-}$$

4. **Using cation exchange resins**
5. **Bipolar membrane electrodialysis.**

Winery management of high pH juice values (continued)

Ignore pH values and secure microbial stability by:

- adding yeast very early (36-48 hours) during a 60º F cold soak to flood the system with *Saccharomyces cerevisiae* and not allow *Brettanomyces* or *Lactobacillus* to get started.
- Final wine still at pH 3.9, but microbially stable and can withstand long aging.

How can high juice potassium be addressed in the vineyard?

Plan your vineyard installation based on a soil analysis !

1. If soil potassium values are already high (greater than 250 to 300 mg/kg soil ammonium acetate extract), then choose rootstocks with Berlandieri parentage.
2. Do not use 101-14, Riparia Gloire, or 1616C, if soil is high in potassium, because they hoard potassium.
3. Do use 420A, 110R, 1103P because they have low uptake thresholds for potassium.

How can high juice potassium be addressed in the established vineyard?

1. Only add potassium if leaf tissue analysis indicates a deficiency:
    1. Bloom Petioles
    2. Bloom Blades
    3. Veraison petioles
    4. Veraison blades

2. Do not shot-gun N-P-K fertilizers, unless the vines truly need all three nutrients.

3. Apply high rates (4 to 8 tons/acre) of Gypsum (calcium sulfate) to leach excessive potassium. This takes 2-3 years to leach potassium out of rootzone, and 1st year will have high potassium as the potassium is pushed off of the Cation Exchange Capacity by the calcium and becomes even more available.

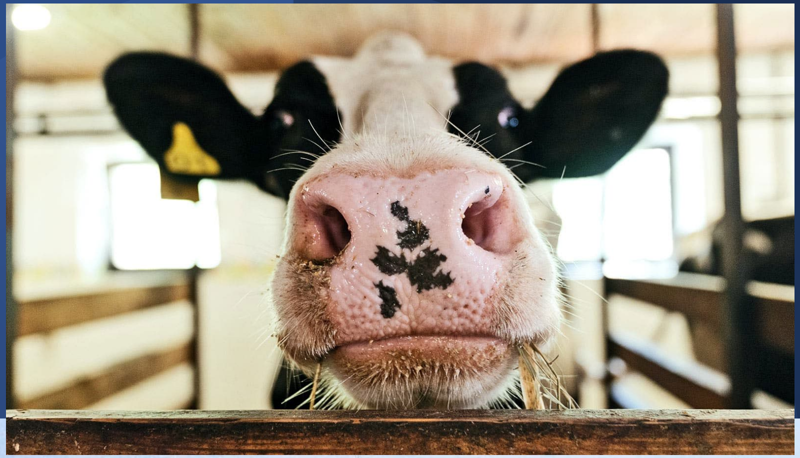
Stage of Growth		K %
Petioles Bloom-time	Deficient	<1.00
	Marginal	1.00 - 1.50
	Adequate	1.50 - 2.50
	Elevated	2.5-3.0
	Excessive	>3.0
Petioles Veraison	Deficient	< 0.75
	Marginal	0.75 - 1.0
	Adequate	1.0 - 1.5
	Elevated	1.5 - 3.0
	Excessive	> 3.0
Blades Bloom-time	Deficient	<0.60
	Marginal	0.60 - 0.75
	Adequate	0.75 - 1.25
	Elevated	1.25 - 2.0
	Excessive	>2.0
Blades Veraison	Deficient	< 0.50
	Marginal	0.50 - 0.80
	Adequate	0.8 - 2.0
	Elevated	2.0 - 3.0
	Excessive	>3.0

How can high juice potassium be addressed in the vineyard?

4. Organic growers should avoid or alternate the use of Grape Pomace Compost with animal manures due to high concentrations of potassium in grape pomace.

5. Monitor all chemistries available:
   A. Soil chemistry
   B. Leaf tissue chemistry
   C. Wine Juice Chemistry

   and detect potential problem early rather than too late.



Managing YAN from the Vineyard

1. **What is YAN?**

   Yeast Assimilable Nitrogen

2. **What are the components of YAN?**

   A. amino acids

   B. ammonium ions, and

   C. small peptides

These constitute what is commonly referred to as yeast assimilable nitrogen (YAN) or fermentable nitrogen

Why is it important and what are the preferred ranges?

YAN has the most impact on:

A. Fermentation speed compared to other compounds.

B. It impacts yeast biomass at the beginning of fermentation and sugar transport during fermentation.

C. At the end of growth phase, N is depleted resulting in decreased protein synthesis and sugar transport. A YAN addition at this point reactivates protein synthesis and sugar transport increasing the fermentation rate.

D. Oxygen is rapidly consumed in the beginning of fermentation. Decreased oxygen inhibits sterols and fatty acid synthesis by yeast. This causes decreased yeast growth and viability at the end of fermentation.

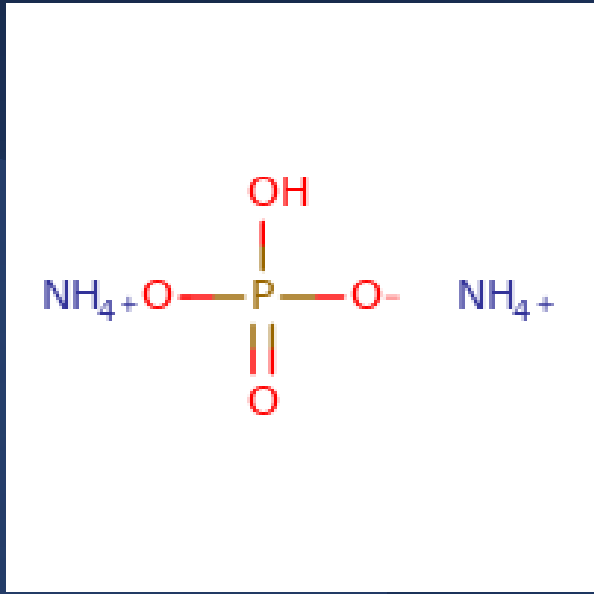
What are the preferred ranges?

Status	YAN	Issues
Deficient	< 150 mg/L	stuck fermentations
Marginal	150 to 200 mg/L	slow or stuck fermentations - hydrogen sulfide
Adequate	200 to 400	optimal
Excessive	> 450 mg/L	stimulate over produciton of ethyl acetate, haze-causing proteins, urea and ethyl carbamate, and biogenic amines

Molly Kelly, Enology Extension Educator: Why, When, and How to Measure YAN. 2020.
Penn State Extension Wine & Grapes

Managing low YAN in the winery

Diammonium Phosphate (DAP): two amino groups per molecule. Likened to a "sugar rush" compared to a complex wholesome meal.



FERMAID-O: Blend of highly specific inactivated yeast fractions (dead yeast carcasses) that are rich in assimilable amino acids (organic nitrogen), small peptides, essential vitamins, and minerals.

Lowers peak fermentation temperatures and improves fermentation kinetics (especially at the end of fermentation), resulting in fewer sulfur off odors like H_2S.

Managing low YAN in the winery (continued)

Superfood® (contains ~30% DAP) is a blend of yeast hulls, vitamins and minerals, rich in the complex nutrients needed for complete fermentation.

Managing low YAN in the Vineyard

CAUTION: Trying to increase YAN in the pre-harvest fruit is prone to risk of the YAN in the harvested fruit being too high. It is easier to increase YAN than reduce it.

Non-Organic:

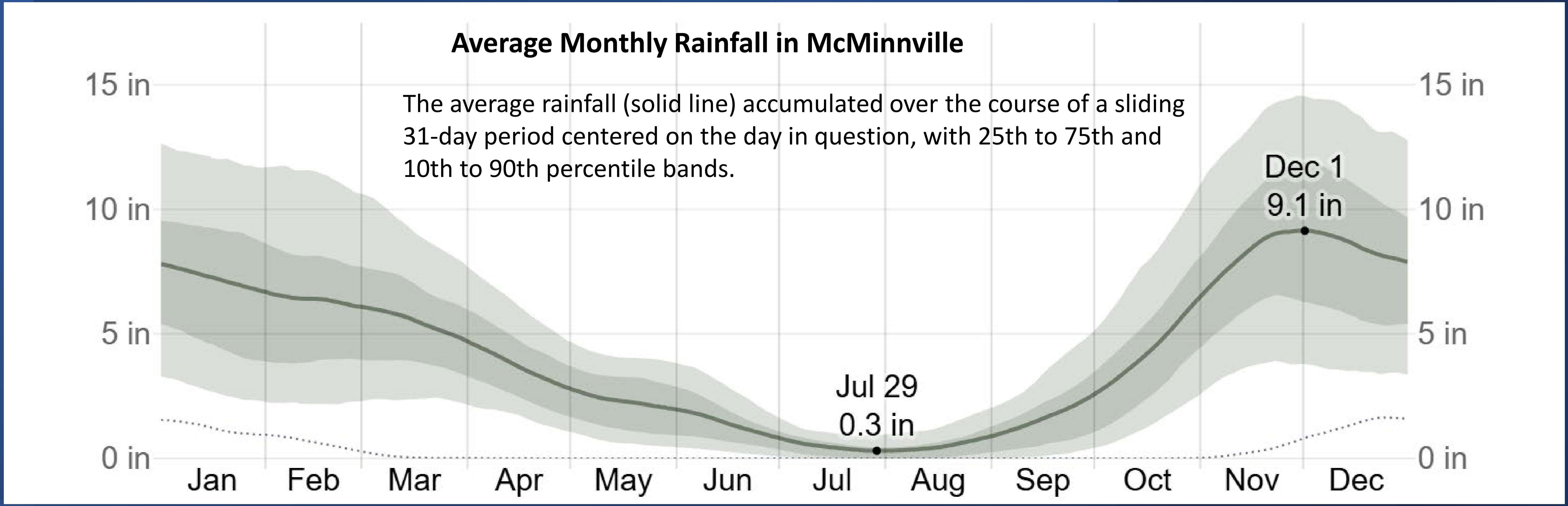
Inject low dose Calcium nitrate (3 gallons/acre CAN-17) 2 weeks after veraison. Requires drip irrigation.

Foliarly apply Urea (5 lbs./acre N) just after veraison.

Organic:

Biomin N (5-0-0) organic foliar fertilizer or equivalent (2 gallons/acre) several weeks after veraison. (Hydrolyzed proteins amino acids).

If there are summer rains: apply composted organics into the cover crop.
Extreme heat (>95°F will volatilize NH_4)



Average Monthly Rainfall in McMinnville

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Rainfall	**7.3″**	**6.4″**	**5.5″**	**3.7″**	**2.3″**	**1.4″**	**0.4″**	**0.4″**	**1.6″**	**4.2″**	**8.4″**	**8.6″**

Vineyard Nitrogen Assessment

1. Check petiole or blade chemistry to determine likelihood of a Nitrogen deficiency and thus low YAN.
2. Compare leaf color of basal versus mid-cane leaves:
   A. If basal leaf is paler green than mid-cane then suspect a deficiency
   B. If basal leaf is same or darker green then probable sufficiency

Stage of Growth		Total N %
Petioles Bloom-time	Deficient	<0.5
	Marginal	0.5 - 0.75
	Adequate	0.75 - 1.25
	Elevated	1.25 - 1.50
	Excessive	>1.50
Petioles Veraison	Deficient	< 0.4
	Marginal	0.4 - 0.5
	Adequate	0.5 - 0.7
	Elevated	0.7 - 1.0
	Excessive	> 1.0
Blades Bloom-time	Deficient	<2.0
	Marginal	2.0 - 2.5
	Adequate	2.5 - 3.0
	Elevated	3.0 - 3.5
	Excessive	> 3.5
Blades Veraison	Deficient	<2.0
	Marginal	2.0-2.5
	Adequate	2.5 - 3.25
	Elevated	3.25 - 3.75
	Excessive	> 3.75

Summary K - pH

The impact of excessive potassium on berry juice pH values can be largely managed by:

1. Vineyard activities such as:
   A. rootstock selection based on soil potassium concentrations (pre-plant soil analysis)
   B. Application of potassium fertilizers only when plant tissue data indicates a deficiency or near deficiency, and
   C. Monitored applications of composted organic matter (grape pomace and manures) over time to avoid excessive potassium loading.

2. Winemaker treatments of high pH juice typically includes:
   A. Addition of tartaric acid
   B. Blending with higher acidity (lower pH) wines
   C. Equipment such as cation exchange resins and/or bipolar membrane electrodialysis

Summary YAN

Managing low YAN in the Vineyard

1. Non-Organic:
   A. Inject low dose (3 gallons/acre) Calcium nitrate 2 weeks after veraison (requires drip irrigation).
   B. Foliarly apply Urea (5 lbs./acre N) just after veraison.

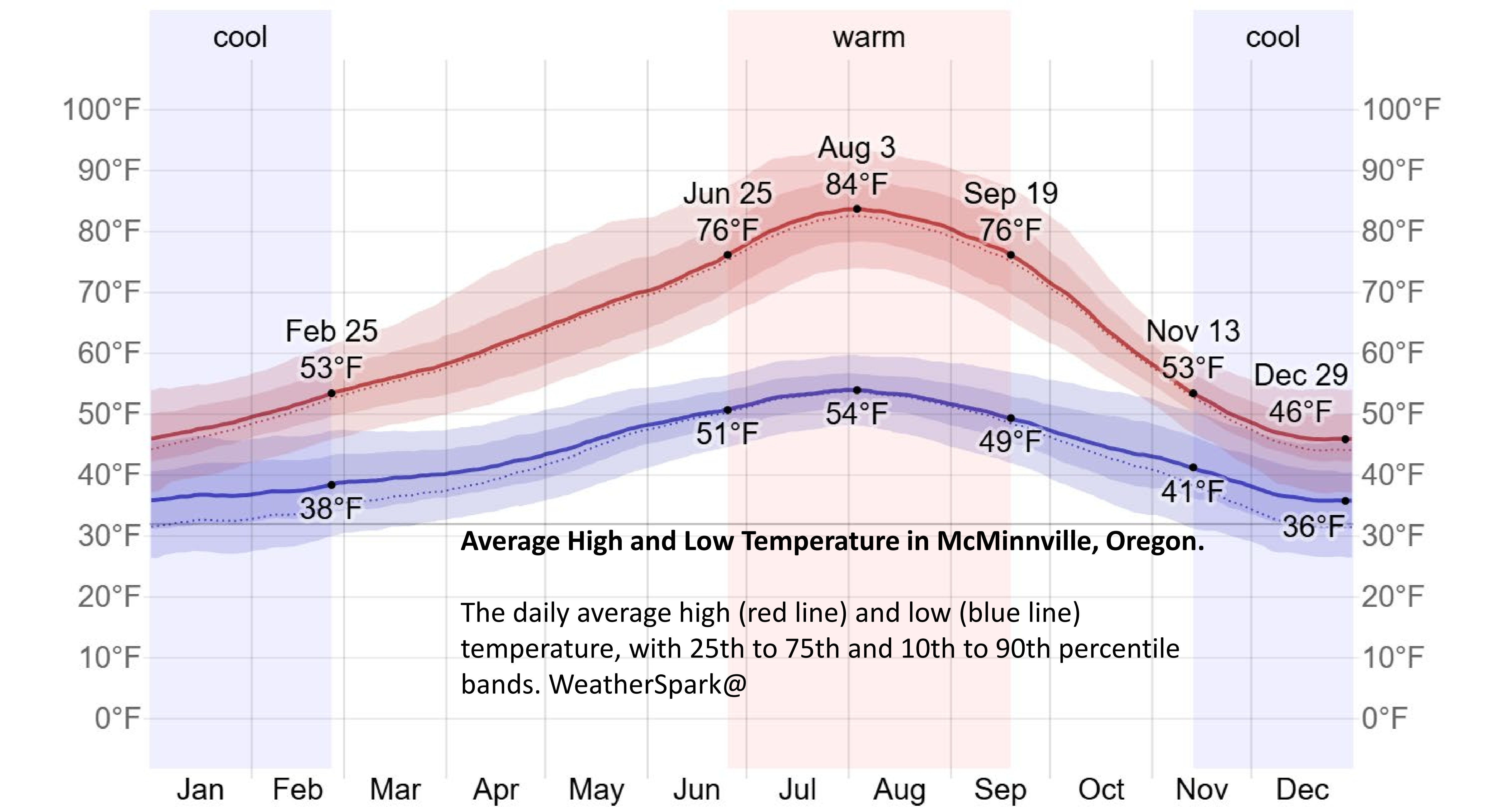
2. Organic:
   A. Biomin N organic foliar fertilizer or equivalent several weeks after veraison.
   B. If there are summer rains: apply composted organics into the cover crop. Extreme heat (> 95°F will volatilize NH_4)

Managing low YAN in the Winery

A. Diammonium Phosphate (DAP)
B. FERMAID-O (organic yeast hulls composed of amino acids)
C. Superfood® (contains ~30% DAP)

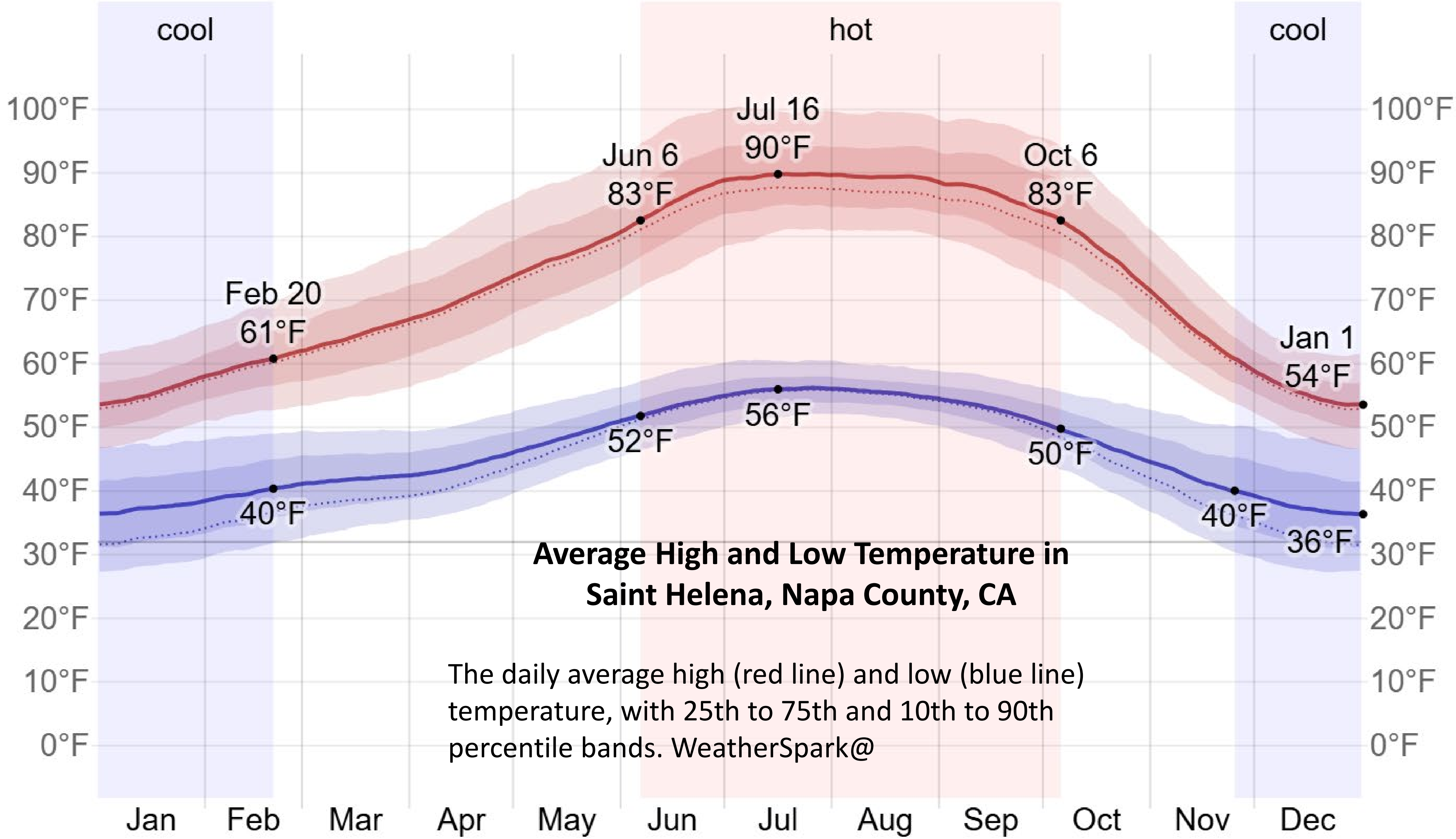
What about Heat?

Temperatures greater than 107ºF will cause severe degradation of important wine chemistry components



Average High and Low Temperature in McMinnville, Oregon.

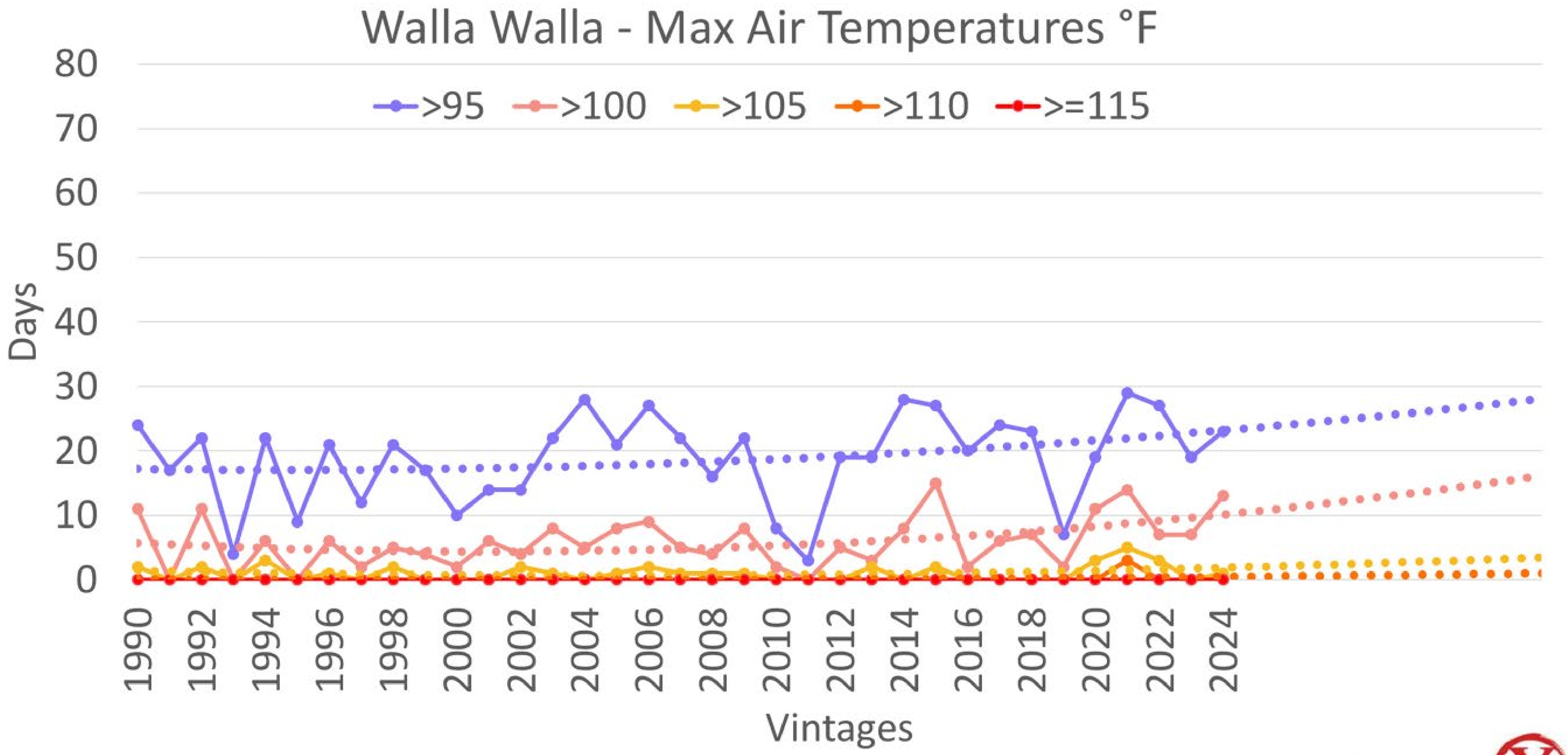
The daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. WeatherSpark@



Average High and Low Temperature in Saint Helena, Napa County, CA

The daily average high (red line) and low (blue line) temperature, with 25th to 75th and 10th to 90th percentile bands. WeatherSpark@

Historical Weather Data – Walla Walla, WA 1990-2024

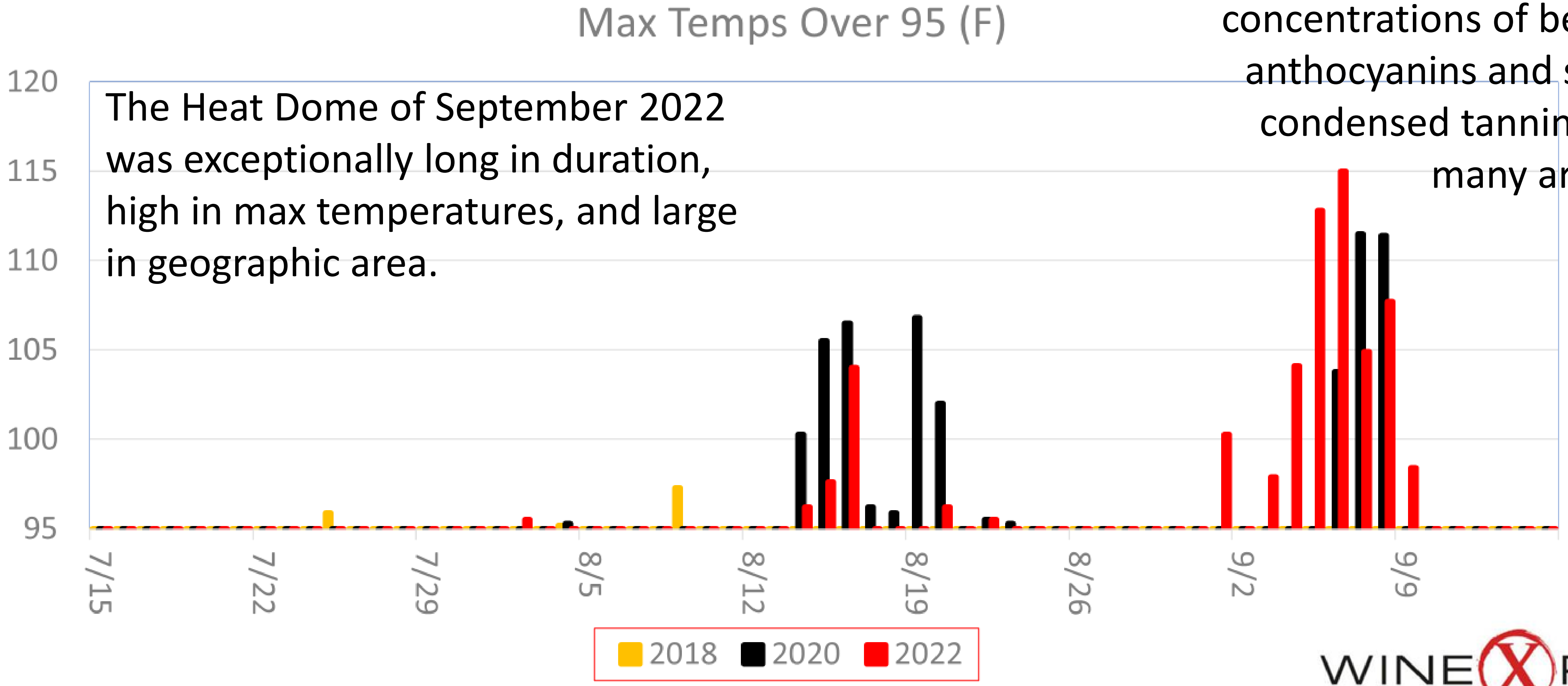


WINE X RAY

Veraison Weather Data– Oakville Field Station, Napa 2018 vs 2020 vs 2022

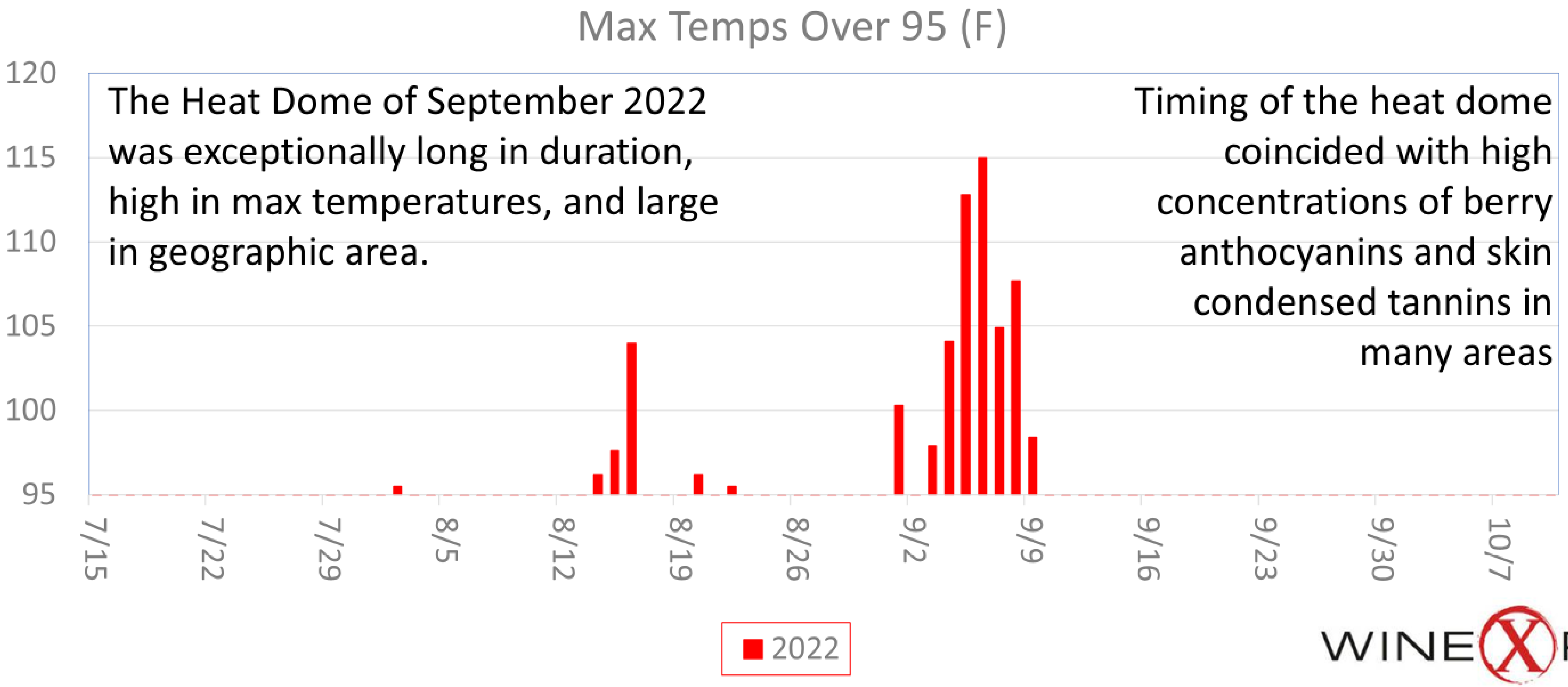
Timing of the heat dome coincided with high concentrations of berry anthocyanins and skin condensed tannins in many areas

The Heat Dome of September 2022 was exceptionally long in duration, high in max temperatures, and large in geographic area.

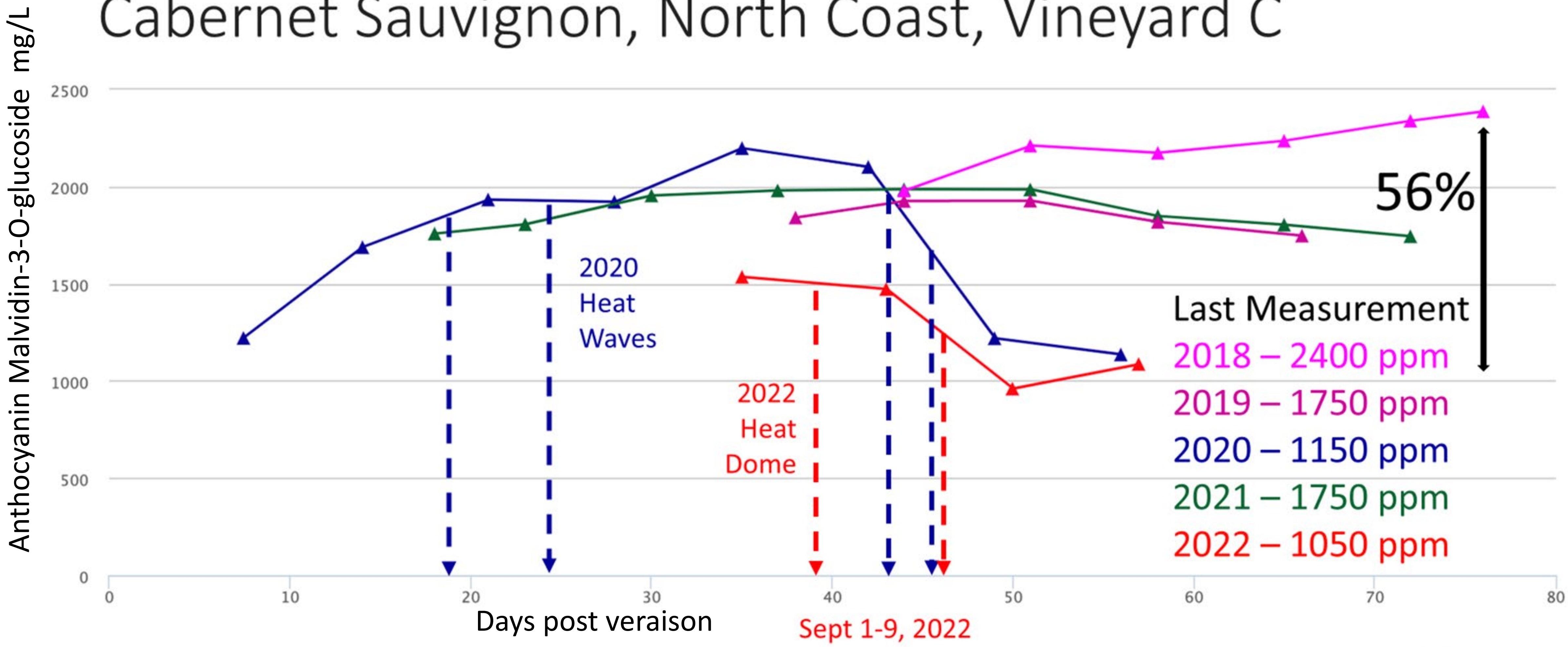


WINE X RAY

Veraison Weather Data – Oakville Field Station, Napa September 1-9, 2022 Heat Dome

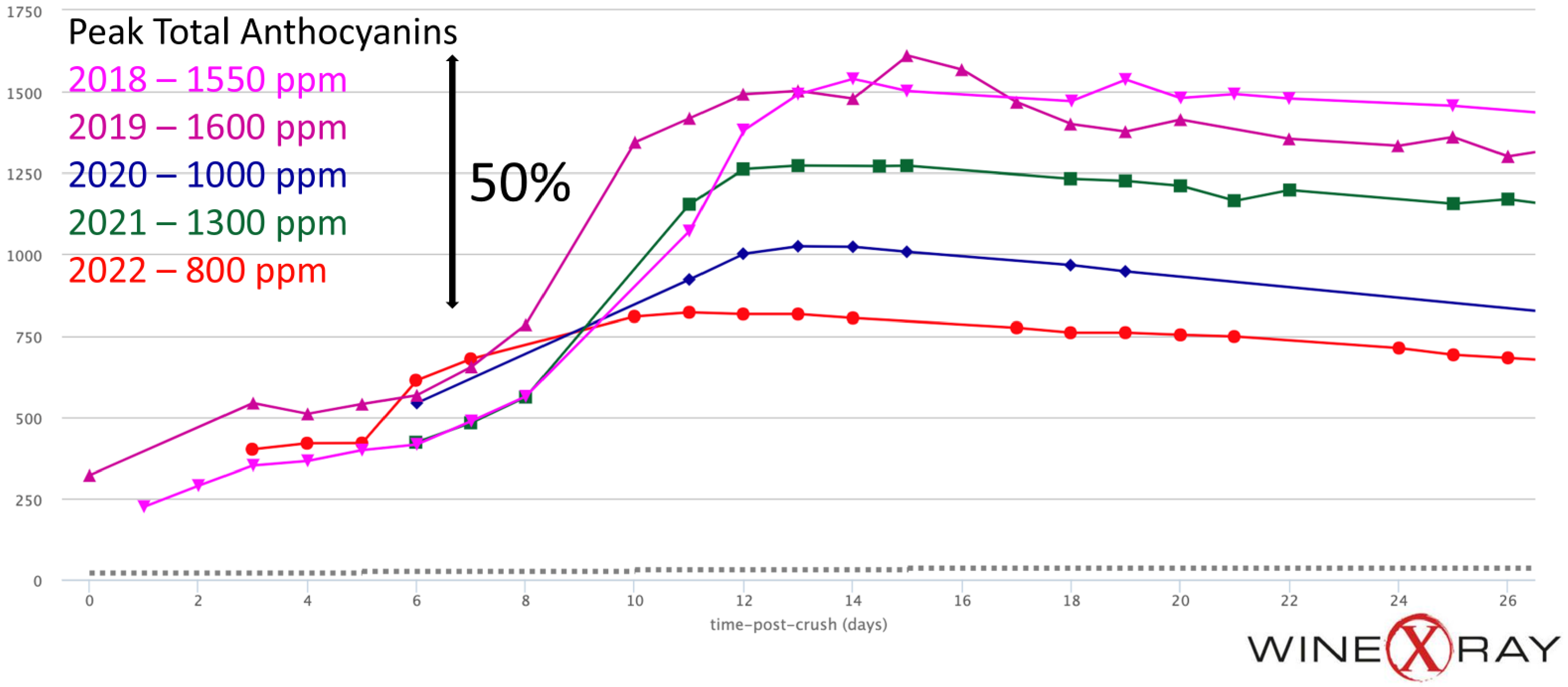


Berry Extractable Anthocyanins – Five Vintages, Cabernet Sauvignon, North Coast, Vineyard C

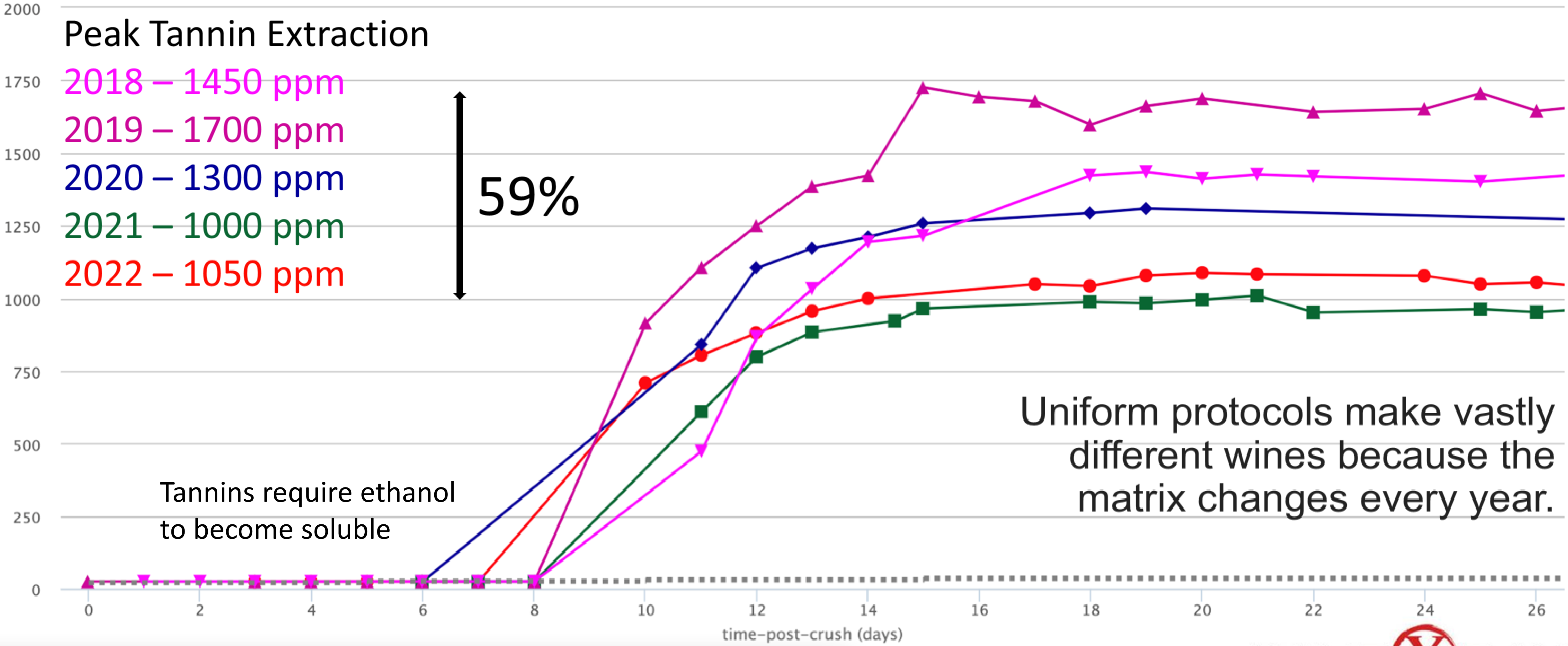


WINE X RAY

Wine Macerations – Total Anthocyanins, Five Vintages, Cabernet Sauvignon, North Coast, Vineyard C



Wine Macerations – (p-p) Tannins, Five Vintages, Cabernet Sauvignon, North Coast, Vineyard C



WINEXRAY

How to manage this in the Vineyard

!!!! Keep in mind that red grapes in direct sunlight can get 15º F hotter than the ambient shade temperature !!!

1. Misters – lower temperature and increase humidity – prone to plugging
2. Shade fabric – Protects the fruit – labor intense

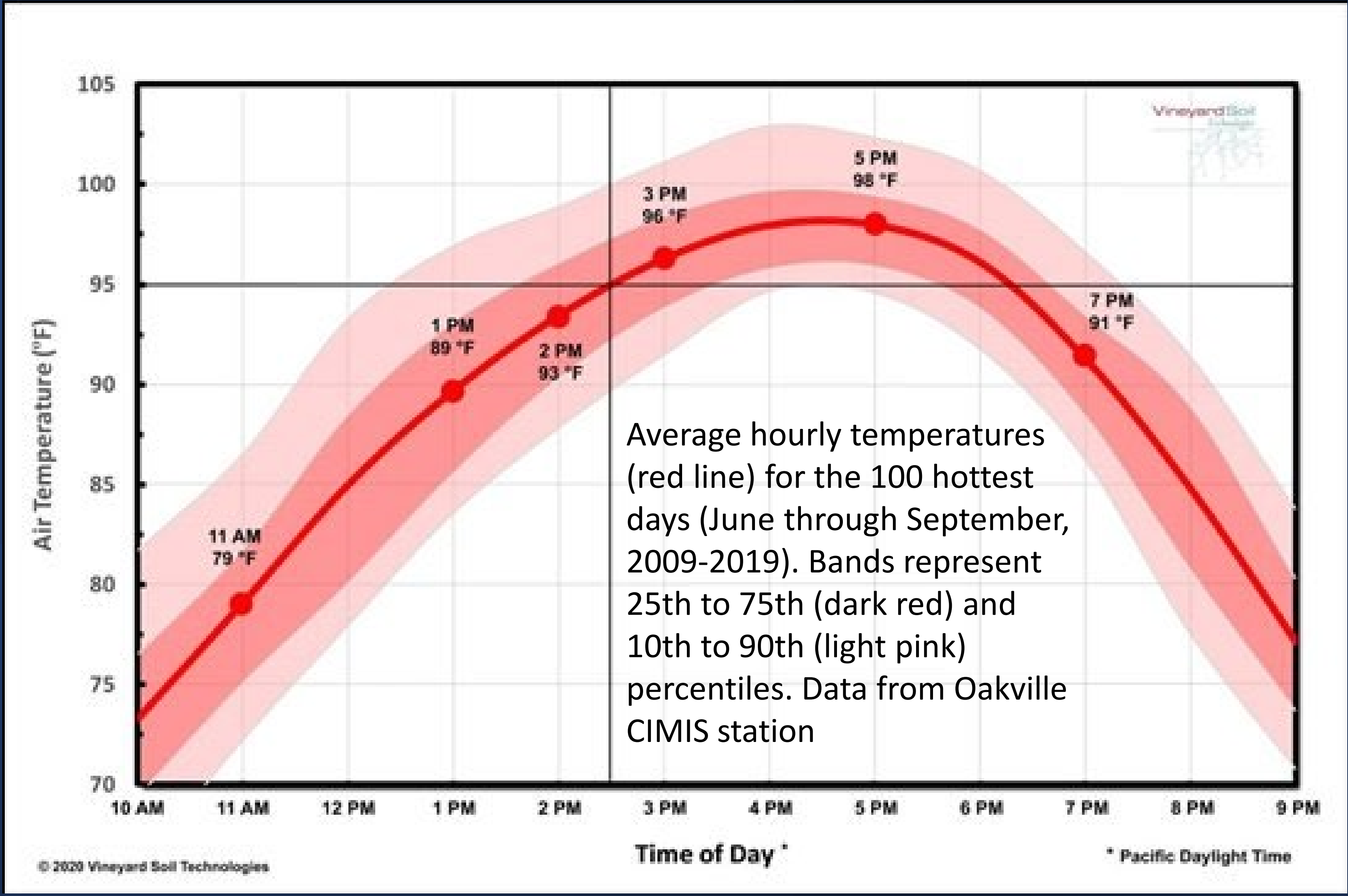
A fine mist provides canopy cooling during heat waves in a 'Cabernet Sauvignon' vineyard.

How to manage this in the Vineyard

Hottest time of day is usually 2:30 to 4:00 PM

Temperatures greater than 107º F will start to cause degradation of important wine components.

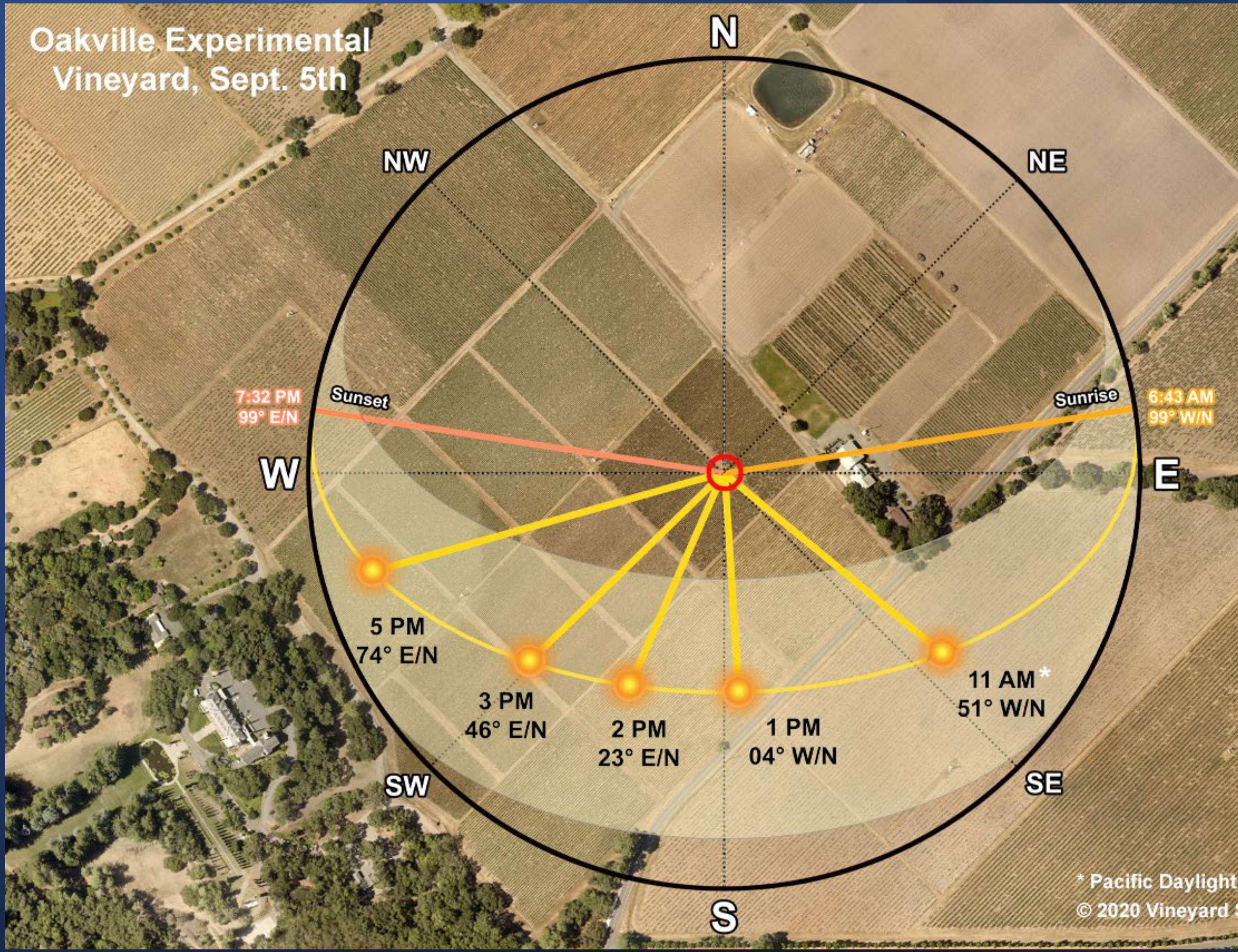
Red grapes in direct sunlight can get 15º F hotter than the ambient shade temperature



How to manage this in the Vineyard

However, the grapes need to be protected from direct sunshine from 95º F onwards, which is reached around 12:30 to 1:00 PM on those hottest days.

Therefore, a row orientation between N-S (00º) and 20º East of north, is optimal to allow lateral removal on the East side to get morning sun on the clusters, and yet still protect the grapes after 1:00 PM with the laterals on the West side.



https://aa.usno.navy.mil/data/AltAz

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