72nd Annual

LODI GRAPE DAY

HOSTED BY

Lodi Chamber of Commerce Agribusiness Committee
UC Cooperative Extension of San Joaquin County

February 6th, 2024 • Hutchins Street Square

AGENDA

7:30 AM **Registration and DPR Credit Sign-In**

8:00 AM **Welcome & Introduction**

8:05 AM **Lodi Grape Growing Season 2023: Year in Review**
Justin Tanner, PhD, Viticulture Farm Advisor, San Joaquin and Stanislaus Counties, UCCE

8:35 AM **Soil Health Variability Assessment in Lodi Vineyards**
Noelymar Gonzalez-Maldonado, PhD Candidate, UC Davis

9:05 AM **Overview of Two Decision-Support Systems for Vineyard Water Management**
Lee Johnson, CSU Monterey Bay, Dept. Applied Environmental Science

9:35 AM **Break**

9:50 AM **Potassium Nutrition in Grapes**
Matthew Fidelibus, PhD, Cooperative Extension Specialist, Kearney Agricultural Research & Extension Center, UCCE

10:20 AM **Losing the Rootstock Freedom: Rootstock Options in a Post-Freedom San Joaquin Valley**
Karl Lund, PhD, Viticulture Farm Advisor, Merced and Mariposa Counties, UCCE

10:50 AM **Lodi's Long-Term Strategy for Getting a Grip on Mealybugs & Viruses: Let's Make a Plan**
Stephanie Bolton, PhD, Plant Pathologist, Lodi Winegrape Commission

11:20 AM **Closing Remarks**
Jerry Fry, President & CEO, Mohr-Fry Ranches

11:30 AM **Lodi Wine Sensory Evaluation**

12:00 PM **Lunch**

12:20 PM **Luncheon Keynote Speaker: Corey Beck**
Executive VP Winemaking, Delicato Family Wines

Meeting Credits = 2.5 hours DPR CE credits in OTHER category

Register for the morning educational session and the luncheon at the Lodi Chamber of Commerce website: lodichamber.com/grape-farm-safety-days

LODI 100 CELEBRATION CHAMBER

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

LODI GRAPE DAY

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Dr. Stephanie Bolton	*Lodi Winegrape Commission*
Jerry Fry	*Mohr Fry Ranches*
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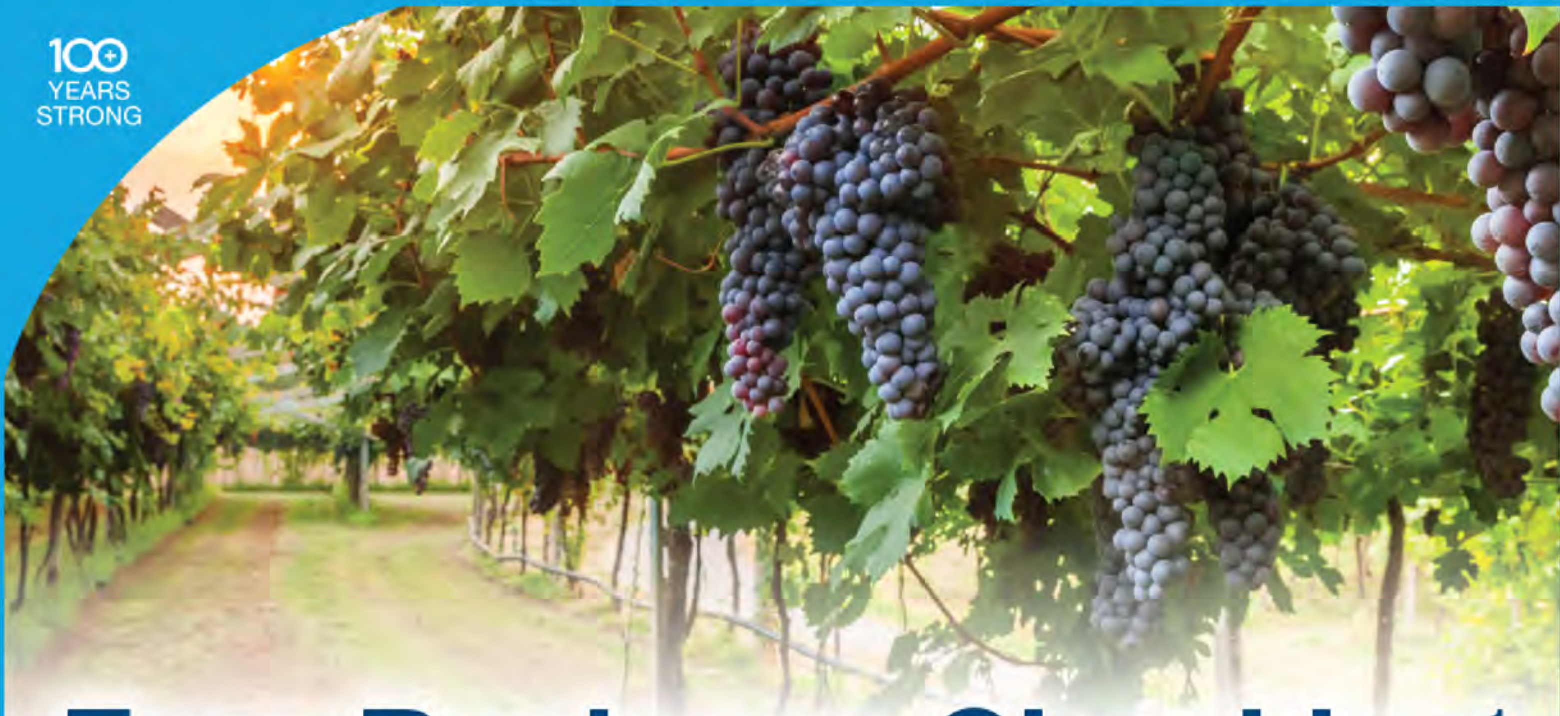
Sara Meidinger	*Bank of Stockton*
Daniel Meza	*F&M Bank*
Dr. Justin Tanner	*UCCE San Joaquin County Viticulture Farm Advisor*
Natalie Collins	*California Association of Winegrape Growers*
Nicole Goehring	*Chief of Staff, Supervisor Ding - District Four*



LUNCHEON KEYNOTE SPEAKER

Corey Beck

EVP of Production & Winemaking Chief Corey Beck has more than 20 years of experience in the wine industry. Corey began his career in viticulture quite by accident, tagging alongside his grandfather who was the vineyard manager for Napa Valley's renowned Chateau Montelena. Born and raised in Calistoga, Corey spent summer vacations working in the vineyards. Upon earning his degree in Fermentation Science from the University of California at Davis, Corey returned to Chateau Montelena as their Cabernet Sauvignon Cellar Master, working with grapes his grandfather had planted in the 1970s–from the same vineyards that gained international recognition in the famous Judgment of Paris tasting. Wanting to broaden his repertoire, Corey joined Inglenook (formerly Rubicon Estate, Niebaum-Coppola) in 1998 as their assistant winemaker.

In 2006, the Coppola family purchased the historic Château Souverain property in Sonoma County, providing a home for the ever-popular Diamond Collection wines, and appointed Corey as director of winemaking and general manager. In the four years following what would become Francis Ford Coppola Winery, Corey worked alongside Francis to help revitalize the property and expand the wine operation. In 2010, after extensive renovations, the winery debuted new tasting rooms, two restaurants, a swimming pool, and more. Not only did Corey oversee major components of the hospitality renovation, he also made improvements to the bottling line and winemaking facility, growing the wine portfolio to encompass distinct Sonoma County wines. In 2013, he spearheaded the purchase of the former Geyser Peak facility and vineyard acquisition and transformed that property over the next few years into what is now Virginia Dare Winery. In 2014, Corey was promoted to president of The Family Coppola's winegrowing endeavors in Sonoma County, managing all business operations, while simultaneously continuing his role as director of winemaking. In 2018, Corey Beck was appointed to CEO of The Family Coppola. He led the company through the merger of Delicato Family Vineyards in 2021 and currently holds the title of EVP Production and Chief Winemaker.

A respected member of the Sonoma County community, Corey is a past president of the Sonoma County Vintners and is regularly involved in a variety of wine industry symposiums and advisory councils. In November of 2017 and 2019, Wine Business Monthly named Corey one of the "Top 50 Leaders," one of the most sought-after wine industry recognitions. When asked about his true winemaking passion, Corey's answer is always Petite Sirah. It's not just Corey's favorite varietal, it was a passion of his grandfather's and one of the primary reasons Corey chose winemaking as a career.

"Harvest is not only about turning grapes into wine, but it's a reflection of Mother Nature's work throughout the growing season." – Corey Beck

DELICATO

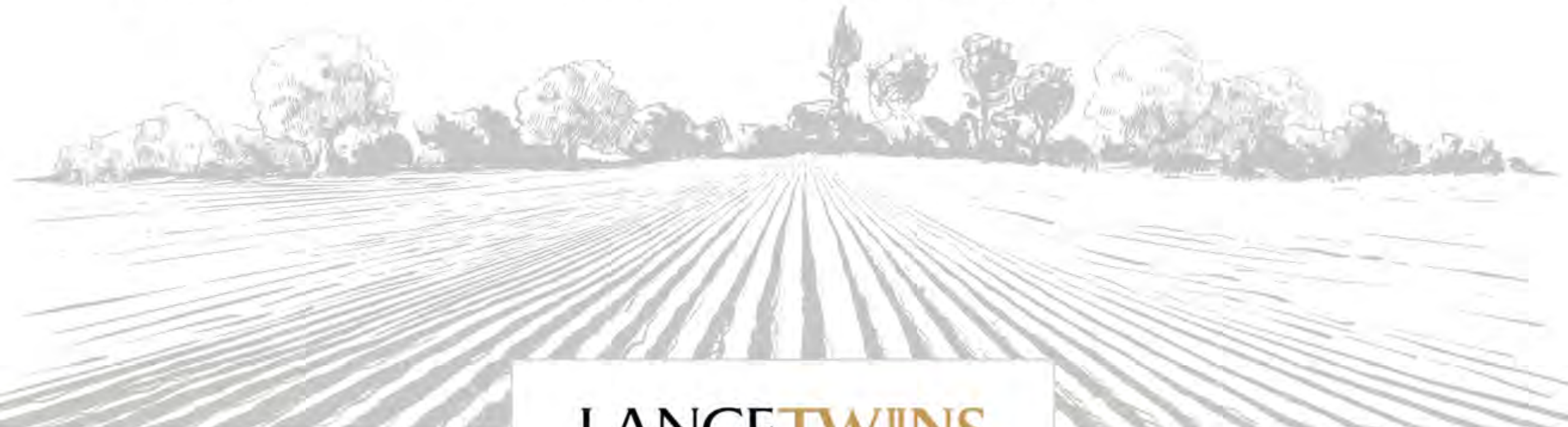
2023 AGRIBUSINESS PERSON OF THE YEAR

Aaron Lange

In the heart of Lodi, California, fifth-generation farmer Aaron Lange is making waves in the wine industry as the Vice President of Vineyard Operations for LangeTwins Family Winery and Vineyards. Born and raised in Lodi, Aaron seamlessly blends his agricultural roots with a passion for sustainability, community, and innovation. Armed with a Bachelor of Science in Viticulture and Managerial Economics from the University of California, Davis, he gained international experience at Viña Ventisquero Winery in Chile before returning to his family's vineyards.

Aaron's role at LangeTwins extends beyond viticulture, encompassing client relations, grape sales, business administration, and spearheading sustainability initiatives. His leadership extends to influential positions in organizations such as the California Association of Winegrape Growers (CAWG) and the California Sustainable Winegrowing Alliance (CSWA). The Lodi Winegrape Commission has also felt Aaron's influence through his active participation in the Lodi Rules and Research & Education Committees. His fingerprints are on significant contributions, including the Second Edition Lodi Winegrowers Workbook and the Lodi Rules for Sustainable Winegrape Growing. Notably, he played a crucial role in establishing the Jahant Appellation Vineyard Alliance in 2019—a testament to his commitment to collaborative solutions against the spread of red leaf viruses and their vectors.

However, what truly sets Aaron apart is his unwavering dedication to community. Actively involved in various committees and boards, he not only benefits LangeTwins but elevates Lodi's standing in the global wine scene. Aaron Lange is not just a vineyard manager; he is a community leader, sustainability advocate, and steward of tradition, leaving an indelible mark on Lodi's viticultural landscape as he cultivates the vines and sows the seeds of a lasting legacy.



LODI GRAPE DAY

February 6, 2024

CONGRATULATIONS TO OUR PAST & PRESENT
AGRIBUSINESS PERSON OF THE YEAR

1967	Robert Carter
1968	Verne Hoffman Sr.
1969	Carl Mettler
1970	Jim Kissler
1971	Ole Mettler
1972	George Schmiedt
1973	Herman Diekman
1975	Leonard Thompson
1976	H.T. Woodworth
1977	Jeryl R. Fry
1978	Adam Van Exel
1979	Emil Bender
1980	Chester M. Locke
1981	John Kautz
1982	George Scheideman
1983	Nobie Matsumoto
1984	Joe Cotta
1985	Ted Holmstrom
1986	Carl Allison Wishek Sr.
1987	Aren Van Gaalen
1988	Philip J. Goehring
1989	Jim Sasaki
1990	Donald Phillips
1991	John Ledbetter
1992	Larry Mettler
1993	Howard Mason
1994	Duan Jungeblut
1995	Claude Brown
1996	Tom Hoffman
1997	Bob Hartzell
1998	Gall Kautz
1999	George Barber
2000	Bruce Mettler
2001	Brad & Randy Lange
2002	Steve Furry
2005	Pat Stockar
2006	Joe Valente
2007	Stanton Lange
2008	Jack Hamm
2009	Rod Schatz
2010	Paul Verdegaal
2011	Joe Peterson
2012	Kim Ledbetter-Bronson
2013	The Phillips Family
2014	Bruce Fry
2015	The Stokes Family
2016	Joe & Sherry Cotta
2017	Brad Goehring
2018	John Anagnos
2019	Amy Blagg
2020	Jennifer L. Spaletta
2021	Paul Burkner

CALIFORNIA'S ORIGINAL SUSTAINABLE WINEGROWING PROGRAM *circa 1992*

created by Lodi farmers and accredited by world-renowned scientists

WHEN YOU DRINK WINE MADE FROM LODI RULES CERTIFIED GRAPES, YOU ARE SUPPORTING

A FARMER, A VINTNER, *and an* ENTIRE AGRICULTURAL COMMUNITY

who embraces their responsibility to care for the environment and the people.

LODI RULES · SUSTAINABLE WINEGROWING · CERTIFIED GREEN

THE **LODI RULES** *seal signifies a third-party audited* **COMMITMENT** *to rigorous, scientifically sound* SUSTAINABLE WINEGROWING

32,812 ACRES *are* CERTIFIED *in* LODI

38,179 ACRES *in* OTHER CALIFORNIA REGIONS

2023

749 ACRES *in* ISRAEL

265 ACRES *in* WASHINGTON

72,005 ACRES TOTAL *in 2023*

"**SUSTAINABILITY** MEANS LEAVING *everything* - PEOPLE, PLACES, ETC - AS GOOD OR BETTER THAN HOW WE FOUND IT."

- Kevin Phillips, Michael David Winery

OVER **100** SUSTAINABLE PRACTICES *are* INCLUDED *in* **LODI RULES**

OVER **200 WINES** *bear the* **LODI RULES** SEAL

A WINE MUST *contain* **85%** *certified sustainable* **GRAPES** *to bear the* LODI RULES SEAL

OVER **25** AVAs AMERICAN VITICULTURAL AREAS HAVE LODI RULES CERTIFIED SUSTAINABLE VINEYARDS

GROWERS *receive a bonus of* $ PER TON FROM *some* **WINERIES** *for:* LODI RULES CERTIFIED GRAPES

$14 MILLION PAID IN BONUSES *since 2010*

DISCOVER WINES MADE FROM LODI RULES CERTIFIED GRAPES AT **lodirules.org**

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- Kludt Oil
- Larry Whitted & Associates
- Mohr-Fry Ranches
- Pan American Insurance

LODI GRAPE GROWING SEASON 2023: YEAR IN REVIEW

Dr. Justin Tanner
UCCE San Joaquin County Viticulture Farm Advisor
Dr. Justin D. Tanner, a plant physiologist and viticulturist, serves as the Northern San Joaquin Valley Viticulture Farm Advisor for UCCE. His role focuses on addressing viticulture challenges in San Joaquin and Stanislaus Counties, and the Lodi American Viticultural Area. With expertise honed at Texas A&M University-Kingsville, Colorado State University, and UC Davis, Dr. Tanner specializes in sustainable agricultural practices, water management, and climate mitigation strategies. He is a committed educator, engaging with the viticulture community through research, field days, and farm calls.

Introduction

The 2023 grape growing season in Lodi, California, was a year of contrasts, presenting a blend of opportunities and significant challenges. While a cooler spring and extra winter rainfall set the stage for an exceptional season, lush vegetative growth, and above-average yield; it also delayed bud break thus delaying the season by several weeks. The 2023 season also rewarded properly timed canopy management such as dormant pruning, shoot thinning, and leaf removal where applicable by reducing disease pressure. For many vineyards located close to rivers, creeks, floodplains, and low-lying areas, especially in poorly drained soils, vineyard access was restricted due to flooding during the early spring months further complicating management decisions (Figure 1).

Figure 1: Vineyard flooding was an issue for many sites this past spring due to record-high precipitation during the winter and spring months. This flooding restricted site access posing additional challenges for early-season canopy and disease management.

Wet and Cool Conditions: A Blessing or Curse?

The 2023 season's cooler spring and early summer temperatures and abundant winter and spring rainfall, while a welcomed relief from recent drought years and beneficial for invigorating vines and revitalizing soil, also created ideal conditions for fungal diseases like powdery mildew and botrytis as well as the growth of weeds. The wetter year led to rapid canopy growth, resulting in a denser and more shaded microclimate in the fruit zones. These conditions, while fostering vine growth also increased the challenge of managing diseases in a few important ways. Namely, thick canopies retain more humidity and reduce light penetration, increasing the suitability of the inner canopy environment for fungal diseases while decreasing the efficiency of fungicide spray penetration and distribution uniformity, creating pockets of less protected areas within the canopy.

Irrigation: When and How Much?

Another challenge of the early part of the growing season was knowing when to begin irrigation. Starting the season with so much moisture in the soil, most sites didn't need to irrigate at all during late spring and early summer. Irrigating more than is necessary wastes water, wastes money, increases energy consumption from running pumps, and encourages an overly dense canopy which can increase disease pressure. The amount of irrigation water needed is based on how much water is being used by the vines, an amount that changes throughout the season based on vine size and evaporative demand.

Monitoring shoot growth is a good indicator of plant water stress (**Figure 2**) and helps to answer the question of when irrigation is needed. Rapidly growing shoots have long tendrils extending out past the shoot tip, a sign that no water stress is occurring. This is the ideal state for early in the growing season. Under moderate water stress, shoot growth and tendril length slow down to save water and keep from harming the vine or the canopy. It does however trigger redirection of resources away from further canopy development to focus on fruit production. Under slight water stress, tendril length is about equal to the shoot tip. Moderate shoot growth is ideal at around mid-season just before veraison. Shoots growing slowly will have tendrils shorter than the shoot tip and is an ideal growth phase going into veraison. After veraison, the season's canopy is developed, and shoot growth at the tip should stop and no tendrils will be seen at the shoot tip. This is ideal as photosynthates are now mainly going to developing fruit instead of developing more canopy. Moderate water stress has beneficial effects on fruit quality in wine grapes so it's important not to over irrigate. Wilted leaves are a sign that the vines are under severe water stress and need to be irrigated before permanent damage to individual leaves and the canopy occurs. Soil moisture sensors and measurements of stem or leaf water potential using a pressure chamber are also useful to quantify plant water availability and are less subjective than visual assessment.

Figure 2: Shoot growth is highly responsive to water availability and can be assessed visually to evaluate plant water status. Without water, stress shoot growth is rapid allowing vines to quickly build a canopy to capture sunlight. Once an adequate canopy is formed, moderate water deficits will trigger a shift in growth priorities from canopy to fruit production which improves fruit quality.

How Does This Year Compare with Other Recent Years

To put this season's weather into perspective, it is helpful to compare the weather of prior years. The California Irrigation Management Information System (CIMIS) maintains five weather stations across San Joaquin County (cimis.water.ca.gov/default.aspx). Of these five stations, CIMIS #070, located in Manteca, has the longest history of weather data reaching back to the late 1980's. The comparison of weather by years in this article is based on this weather station. When looking back at weather trends over the last 30+ years, we can see some significant differences in 2023. Spring was much cooler than in recent years with the average air temperature during the month of February cooler than any other year in the dataset (**Figure 3**), while the month of March was the second coolest after 2006. Precipitation in 2023 was also considerably more than "normal" and the second highest after 1998 (**Figure 4**). Growing Degree Day (GDD) accumulation over the season was one of the few weather variables in which 2023 was close to the average value across all years (**Figure 5**). Even though 2023 started cooler, late summer and early fall were warm allowing fruit to slowly ripen on the vine. Hang time was so long this past season with many vineyards still harvesting in mid to late November! Regarding high heat days, 2023 received seven days where the maximum daily temperature was 100^0F or above. The first high heat event lasted three consecutive days starting on June 30 until July 2. Additionally, two shorter high-heat events lasted two consecutive days each, with the first from July 16 to July 17 and the second from July 21 to July 22. The incidence of days reaching a temperature of 100^0F has increased in recent years (**Figure 6**).

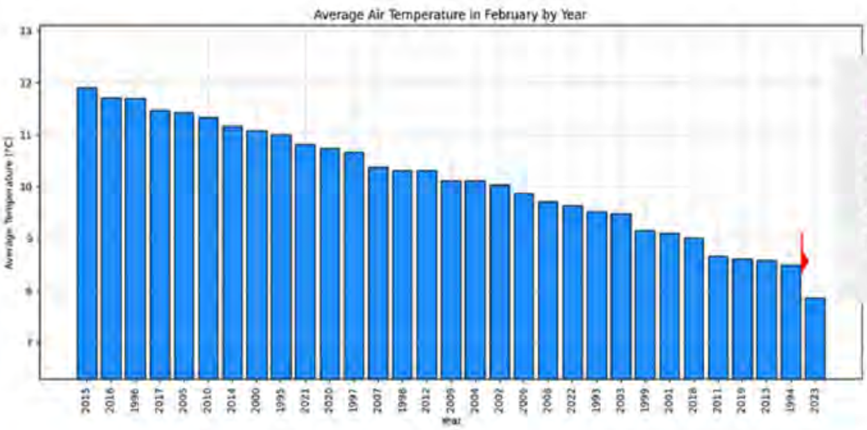
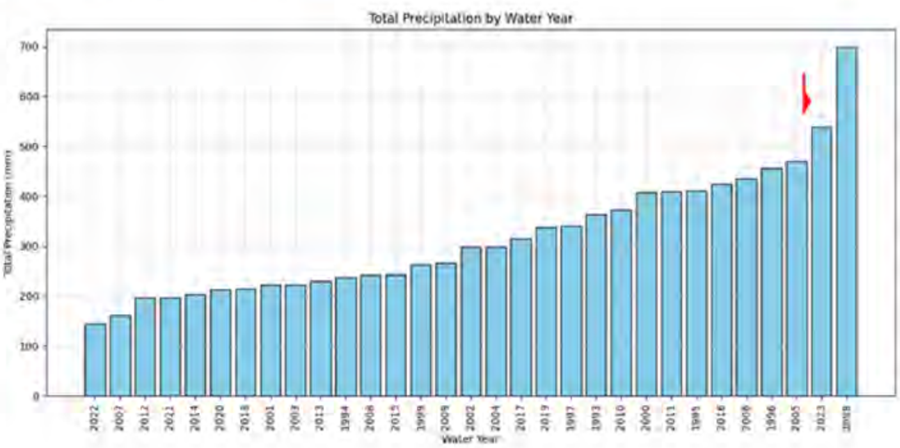


Figure 3: Average air temperatures during the month of February from 1993 through 2023. This past February was the coolest in 30 years at CIMIS Station #70 in Manteca, highlighted with a red arrow.

Figure 4: Yearly precipitation total (November previous year - October current year) highlighting the high rainfall in 2023 (red arrow) compared to the last 30 years. Data from CIMIS Station #70 in Manteca.



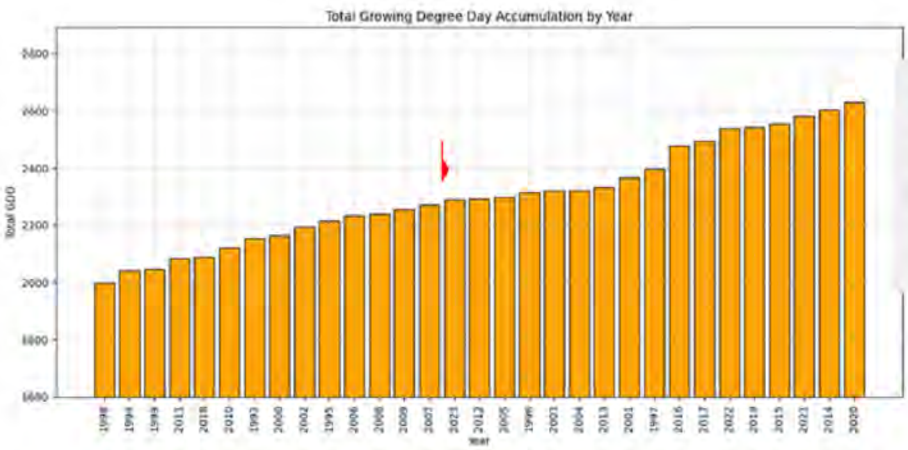


Figure 5: Growing Degree Day (GDD) accumulation over the previous 30 seasons with 2023 highlighted with a red arrow. Data from CIMIS Station #70 in Manteca.

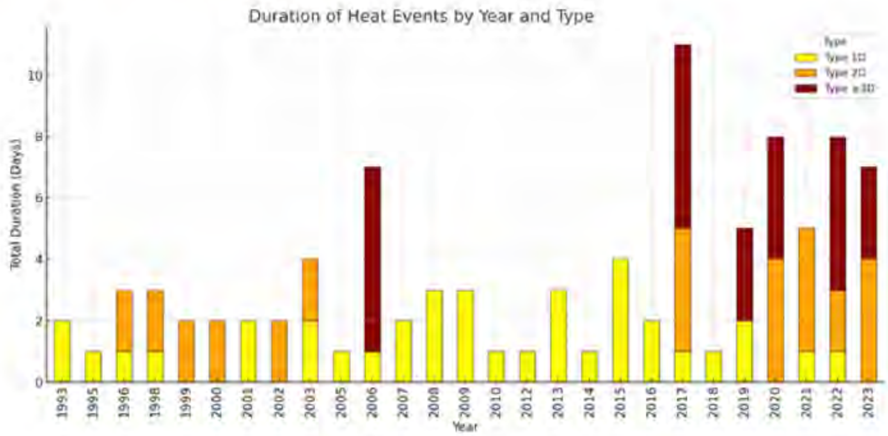


Figure 6: Yearly counts of high heat events over the past 30 years recorded by CIMIS Station #70 in Manteca. Single-day counts where the maximum air temperature was at or above 100⁰F are shown in yellow. Counts of events that lasted two consecutive days are shown in orange. High heat events which lasted for three or more consecutive days are shown in dark red.

Understanding Seasonal Differences Based on Grouping Like Vintages

With so many weather variables contributing to the overall growing season, it is helpful to compare vintages in terms of similarities and differences across weather variables. Employing Principal Component Analysis and K-means clustering, we identified four distinct groups with similar seasonal characteristics (**Figure 7**) based on GDD accumulation, total precipitation, average temperature during the spring, summer, fall, and winter, timing of the last spring frost and the first fall frost, number of frost-free days during the growing season, and the number of days at or above 100⁰F for each year. The characteristics and chronological progression of seasonal weather clusters suggest an increase in hot, dry, and more extreme weather events in recent vintages (**Figure 8**). Of the four vintage groups, the first group (shown in blue in Figures 7 and 8) is distinct for having the highest mean precipitation and the lowest GDD, simply put "Cool and Wet". Even though it represents the coolest of growing seasons, it features a high number of frost-free days compared to other vintage groups. The second vintage group (shown in green in Figures 7 and 8) represents long and warm growing seasons with consistent weather with few days of extreme heat and low incidence of spring frosts. Seasons in this group we have labeled "Warm and Stable".

The third vintage group (shown in orange on Figures 7 and 8) is distinct for having the lowest spring air temperature resulting in a delayed start to the season and increased incidence of late spring frosts compared to other groups. The last vintage group (shown in red in Figures 7 and 8) represents the antithesis of the first group, with the lowest precipitation, highest GDD, and most high heat days of any group.

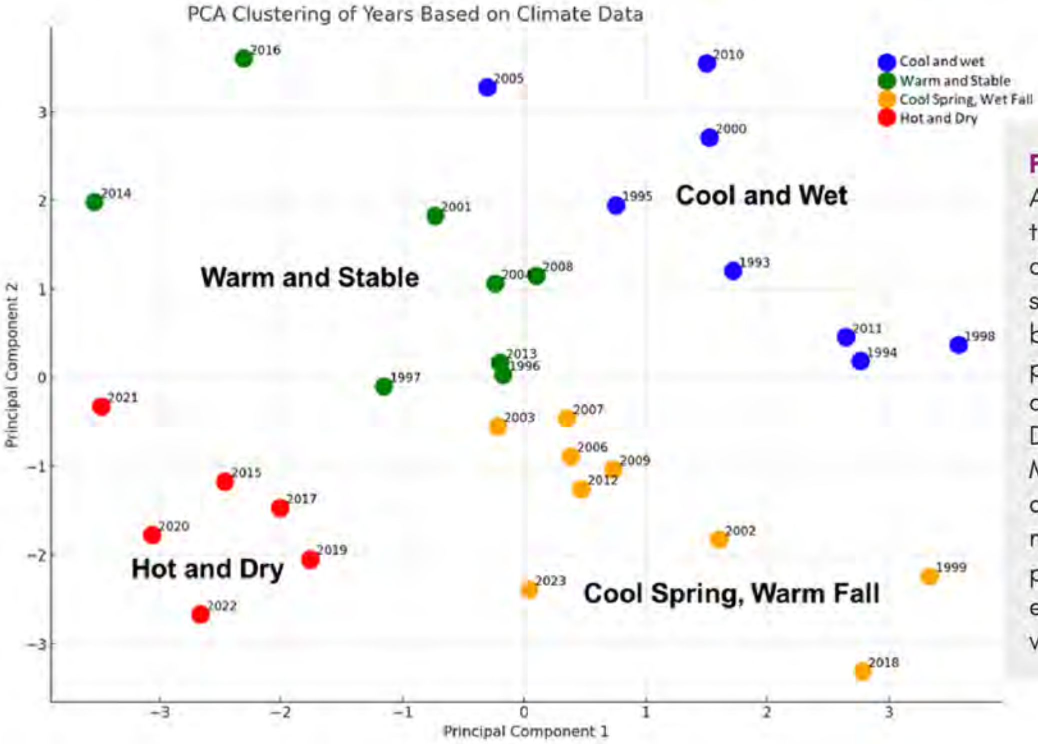


Figure 7: Principle Component Analysis of yearly weather used to visualize similarities and differences between growing seasons. Grouping of vintages based on seasonal weather patterns was performed using a k-means clustering algorithm. Data from CIMIS Station #70 in Manteca. This past season, although unique, was similar to many other vintages over the past 30 years which also experienced a cool spring and warm fall.

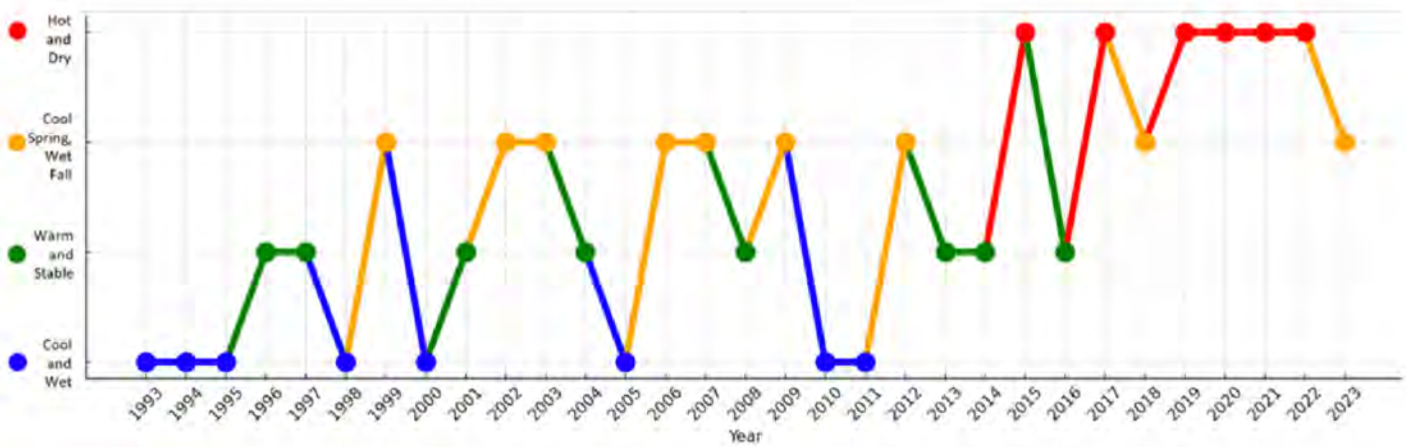


Figure 8: Timeline of Principle Component Analysis seasonal groups over the last 30 years of weather from CIMIS Station #70 data. The weather trends over time suggest a shift to warmer, drier with more frequent extreme weather events such as heatwaves and late spring frosts.

The Prevalent Challenge of Powdery Mildew

Effective management of powdery mildew hinges on vigilant weather monitoring, especially the Powdery Mildew Risk Index (PMRI) to know when and how often to treat for PM during the season, this year it was especially important. While infection risk started a bit later in 2023 not reaching "high" levels until April 23, there was a long period from the end of May until July where pressure stayed at elevated levels requiring vigilant management to prevent infection. Even though 2023 started cool, there were many days with temperatures above 90^{0}F especially in July which increased the chance of burning canopies if sulfur was applied a few days before hot weather (**Figure 9**). With so many days of high PMRI just before hot days in June, many growers were caught playing catch up with sulfur treatment dangerously close to hot weather which began on June 28th increasing the risk of sulfur injury.

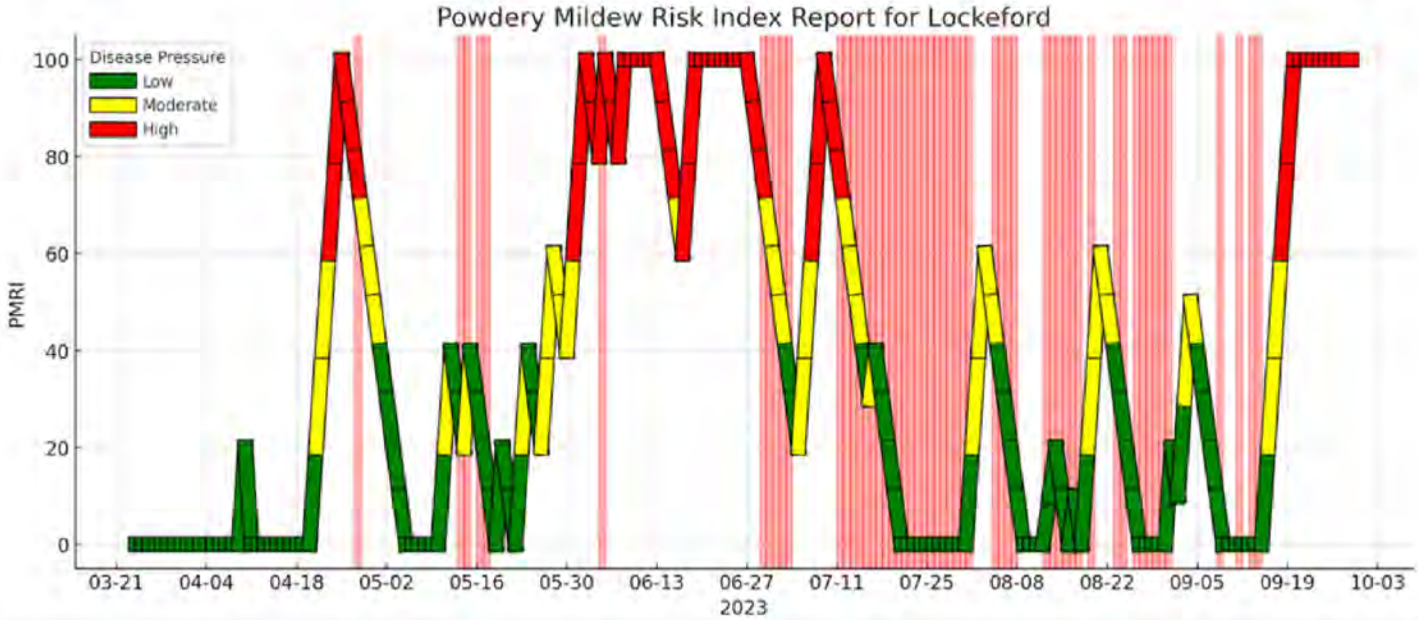


Figure 8: Powdery Mildew Risk Index (PMRI) showing differences in disease pressure across the season in 2023 from UC IPM data from Lockeford. ipm.ucanr.edu/weather/grape-powdery-mildew-risk-assessment-index/stationdata.cfm?stationID=LOC&userYear=2023. PMRI values are shown as a line with the risk of infection rated as a score relating to the suitability of temperature for powdery mildew infection, with low infection risk time points highlighted in green, moderate in yellow and high risk in red. Vertical red lines behind the line graph highlight days with temperatures of 90^{0}F or higher.

Summer Bunch & Sour Rot: Late-Season Hazards

Advancing into the season, the emergence of summer bunch rot and sour rot, caused by several different pathogens, presented new challenges (**Figure 9**), especially in tight-clustered varieties prone to berry splitting. Any injury to the berry skin, whether from powdery mildew scars, insect bites, bird damage, or mechanical injury provides the entry point for infection (**Figure 10**). As 2023 was a big year for many fruit crops, Drosophila fruit flies were also plentiful.

These flying insects scan the area for any injured fruit in which to lay eggs in and spread acetic acid bacteria and yeast which together cause sour rot. Once eggs are implanted, new adults emerge from fruit in 6-8 days and begin the process all over again further spreading the rot. If sour rot-infected fruit is dropped several weeks before harvest and left in the vineyard, the cycle of emergence of fruit flies and spread of sour rot continues unabated. For unsold fruit affected by rot, clusters can remain on the vine until they are removed during dormant pruning however care must be taken to ensure that grapes do not remain on the soil surface at the beginning of the next season (Figure 11). Infected berries will host overwintering structures of pathogens allowing them to get a head start for the next season if left intact. By placing infected fruit in the row middle disking them and incorporating them into the soil along with dormant pruned canes, disease pressure will be lowered at the start of the next season. In areas of the vineyard that have experienced high rot levels in 2023, increasing canopy management efforts and avoiding overirrigation will help to decrease disease incidence this season, potentially saving the crop!

(A) Botrytis, (B) Penicillium, (C) Aspergillus, (D) Cladosporium, (E) yeast

Figure 9 (left): Various summer bunch rot/sour rot symptoms on berries. While there are many different pathogens that can rot berries late in the season, proper canopy management can help to decrease disease incidence for all of them by increasing air flow, light infiltration, and decreasing humidity creating a less favorable environment for the pathogens.

Figure 10 (right): Summer bunch rot will enter through wounds in berry skin when wet and humid conditions provide the proper environment for the pathogen to invade. Infection is opportunistic exploiting any type of injury such as A) powdery mildew scars, B) bird damage highlighted with arrows, C) mechanical damage, or D) cracks in the skin caused by sunburn.

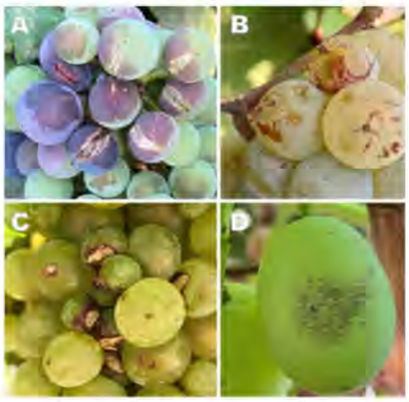


Figure 11 (left): Unharvested grapes affected by summer bunch rot can be the source of inoculum in the next season if allowed to remain in the vineyard. Diseased fruit should be cut off with final pruning, placed in the row middles, and incorporated into the soil before the start of bud burst in spring to reduce disease pressure next season.

Higher Crop Load and Potential to Reduce Ripening Speed

The season was marked by a normal to above-average fruit set, culminating in higher-than-usual crop loads in many vineyards. The reduction in growing degree day accumulation in the spring and early summer meant that fruit ripening was slowed. While this can have benefits in fruit quality relating to a balanced composition of sugars and the retention of acids, this was an issue for vineyard blocks that were having trouble meeting the minimum contract requirements for Brix of ~24^{0} or higher at harvest time. This reduced ripening speed because of higher crop loads is exacerbated when vines are infected with Grapevine Leafroll Associated Virus or Grapevine Red Blotch Virus further diminishing the ability of the fruit to accumulate carbohydrates (sugars).

Conclusion: Looking Forward and the Importance of Tailoring Vineyard Management to Seasonal Differences

The 2023 grape growing season in Lodi was a lesson in the importance of adaptability and proactive disease management. While weather conditions provided an opportunity for an exceptional vintage, they also highlighted the risks of sticking to conventional practices in an unconventional year. The successes and struggles of this season underline the need for continuous monitoring of weather and adaptation in vineyard management in each year, ensuring that we are prepared to face the varied challenges presented by each unique growing season especially as extreme weather events are becoming more frequent.

SOIL HEALTH IN VINEYARDS

Noelymar Gonzalez-Maldonado
Soils and Biogeochemistry PhD Candidate at UC Davis

Soils in California vineyards are highly susceptible to erosion and degradation. Building soil health is essential for the long-term protection and functioning of the soil. Managing soils through conservation or regenerative practices can help protect soils and contribute to vineyard resilience.

WHAT IS SOIL HEALTH?

Soil health is defined by the NRCS as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. Healthy soil supports functions such as good and balanced water holding capacity and infiltration, nutrient cycling and supply for vines, carbon storage, biodiversity, and biological activity, along with other functions that support vine health and grape production. According to a recent needs assessment conducted at UC Davis (Gonzalez-Maldonado et al., in preparation), a healthy vineyard soil is balanced in terms of nutrients and water, that has increased biodiversity, requires minimal inputs and interventions, and is resilient to drastic weather events like droughts and heavy rainy seasons.

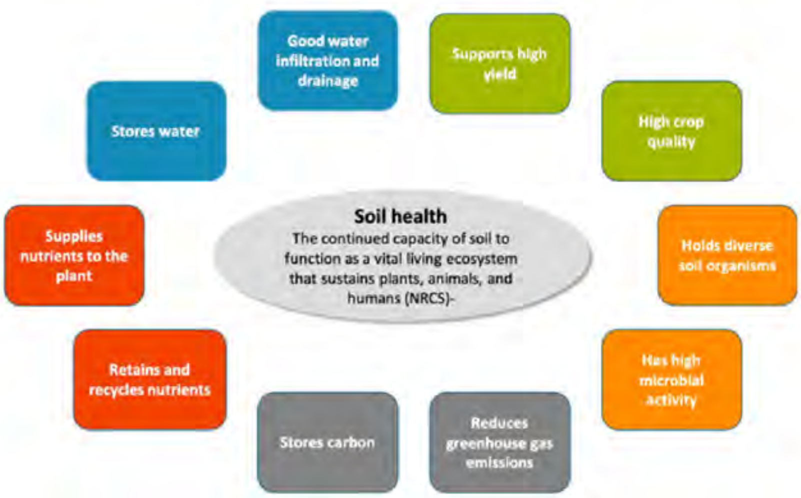


Figure 1. Functions that healthy soil can provide in vineyards. (Lazcano et al., 2020)

HOW CAN WE MANAGE FOR HEALTHY VINEYARD SOILS?

Three methods to build soil health in vineyards are:

1. Practices that increase soil organic matter, such as compost application
2. Reducing soil disturbance through no-till or minimal disking
3. Increasing biodiversity with cover crops or natural cover

1. INCREASING SOIL ORGANIC MATTER THROUGH COMPOST APPLICATIONS

Applying compost increases soil organic matter, soil microbial activity, and nutrients beneficial for vine health. Over time, as vines grow, a decline in soil organic matter is common, as it gets decomposed and cycled by soil organisms. However, replenishing organic matter through the application of organic sources like compost is important to maintain a balanced and healthy soil. Generally, the higher the soil organic matter, the better it is for soil health functioning and resilience.

Figure 2. Example of compost in various processing stages from the darkest color pile on the left, which is more finalized, to the least processed compost pile on the right, needing more processing time. (Picture courtesy of Dr. Joshua Garcia)

2. REDUCING SOIL DISTURBANCE THROUGH NO-TILL OR MINIMAL DISKING

An important benefit of no-till and reduced tillage, such as minimal disking, is protecting soil from erosion. No-till can also increase soil organic matter though these effects are mostly observed when the practice is sustained for several years. Instead of tilling, mowing cover crops or natural cover has been shown to benefit berry attributes like pigment accumulation in red varieties (Lee and Steenwerth, 2013). Other vineyard cover crop management practices such as sheep grazing have been shown to benefit soil health by increasing available soil nitrogen (Lazcano et al., 2022).

3. INCREASING SOIL BIODIVERSITY BY HAVING COVER CROPS OR NATURAL COVERS

Increasing soil aboveground biomass through diversified cover crops can enhance soil organic matter and beneficial microbial functions (Steenwerth and Belina 2008). Living roots create channels in the soil, improving aggregation and aeration, and encouraging biological activity.

Figure 3. Sheep grazing as a method to manage cover crops without tillage or mowing, picture from Tablas Creek vineyard in Paso Robles, CA.

This activity, from microorganisms (fungi and bacteria) as well as earthworms, diverse nematodes, root exudates, among other organisms, contribute towards better nutrient cycling and soil structure, which are beneficial for vine growth and productivity. For example, using cover crops to promote biodiversity has been shown to benefit berry attributes, like increased juice soluble solids, anthocyanin, and other phenolic components while decreasing titratable acidity and pH in wine grapes (Guerra and Steenwerth 2012). Additionally, cover crops can enhance water use efficiency in vineyards (Novara et al., 2021).

Figure 4. Soil sample under cover crops showing the presence of earthworms, indicators of healthy soils.

IN SUMMARY, it is important to remember that building soil health is a journey, not a destination. This journey involves numerous attempts to find the most sustainable and effective practices for your specific vineyard. For more information, feel free to reach out for support from your local UC Cooperative Extension, Resource Conservation District, and NRCS offices as well as the UC Davis Soil Biodiversity and Health website.

References:

Battany, M. C., & Grismer, M. E. (2000). Rainfall runoff and erosion in Napa Valley vineyards: Effects of slope, cover and surface roughness. Hydrological Processes, 14(7), 1289-1304. https://doi.org/10.1002/(SICI)10991085(200005)14:7<1289::AID-HYP43>3.0.CO;2-R

Guerra, B., & Steenwerth, K. (2012). Influence of Floor Management Technique on Grapevine Growth, Disease Pressure, and Juice and Wine Composition: A Review. American Journal of Enology and Viticulture, 63(2), 149-164. https://doi.org/10.5344/ajev.2011.10001

Gonzalez-Maldonado, N., Nocco, M.A., Crump, A., Steenwerth, K.L., Lazcano, C. (In preparation). Understanding Wine Grape Grower Perceptions and Attitudes about Soil Health.

Lazcano, C., Decock, C., & Wilson, S. G. (2020). Defining and Managing for Healthy Vineyard Soils, Intersections With the Concept of Terroir. Frontiers in Environmental Science, 8, 68. https://doi.org/10.3389/fenvs.2020.00068

Lazcano, C., Gonzalez-Maldonado, N., Yao, E. H., Wong, C. T. F., Merrilees, J. J., Falcone, M., Peterson, J. D., Casassa, L. F., & Decock, C. (2022). Sheep grazing as a strategy to manage cover crops in Mediterranean vineyards: Short-term effects on soil C, N and greenhouse gas (N2O, CH4, CO2) emissions. Agriculture, Ecosystems & Environment, 327, 107825. https://doi.org/10.1016/j.agee.2021.107825

Lazcano, C., Gonzalez-Maldonado, N., Yao, E. H., Wong, C. T. F., Falcone, M., Dodson Peterson, J., Casassa, L. F., Malama, B., &

Decock, C. (2022). Assessing the Short-Term Effects of No-Till on Crop Yield, Greenhouse Gas Emissions, and Soil C and N

Pools in a Cover-Cropped, Biodynamic Mediterranean Vineyard. Australian Journal of Grape and Wine Research, 2022, 8100818. https://doi.org/10.1155/2022/8100818

Lee, J., & Steenwerth, K. L. (2013). 'Cabernet Sauvignon' grape anthocyanin increased by soil conservation practices. Scientia Horticulturae, 159, 128-133. https://doi.org/10.1016/j.scienta.2013.05.025

Novara, A., Pisciotta, A., Minacapilli, M., Maltese, A., Capodici, F., Cerdà, A., & Gristina, L. (2018). The impact of soil erosion on soil fertility and vine vigor. A multidisciplinary approach based on field, laboratory and remote sensing approaches. Science of The Total Environment, 622-623, 474-480. https://doi.org/10.1016/j.scitotenv.2017.11.272

OVERVIEW OF TWO DECISION-SUPPORT SYSTEMS FOR VITICULTURE

Lee Johnson CSU Monterey Bay, Dept. Applied Environmental Science
NASA Ames Research Center, Earth Science Division

Lee Johnson is a Senior Research Scientist at Cal State Monterey Bay and is a cooperator with the Earth Science Division at NASA Ames Research Center. He focuses on agricultural applications of remote sensing with emphasis on crop evapotranspiration monitoring. He is a member of the OpenET Technical Team and has collaborated with UC Extension on the Central Coast for the past several years.

Sustainable water management is one of the most challenging issues of our time, especially in the arid western U.S. Adequate water supplies are crucial to maintaining the health of communities, rivers, and wildlife, and nothing is more important to agriculture's ability to produce food for the world's growing population. Maximizing the benefits of our water supplies requires careful measurement of their availability and use. For irrigated agriculture, satellite-based estimates of evapotranspiration (ET) provide a measure of the water used to grow food — the biggest share of water consumption in most arid environments around the world. However, access to ET data has been limited and expensive, keeping it out of the hands of most water users and decision-makers. OpenET provides open, easily accessible satellite-based ET data for water management support. The OpenET collaborative includes leading national and international experts in remote sensing of ET, cloud computing, and water policy, partnered with nationally recognized web development teams and leaders in the western agriculture and water management communities. The system can be accessed at openetdata.org

Transformative, Timely ET Data | An Ensemble of Well-Established Methods | Secure, Custom Data Delivery

eCropManage is an online decision support tool that assists growers and farm managers in determining water and nitrogen fertilizer applications on a field-by-field basis. Automated calculations derive crop water needs from weather data and models of crop development. Fertilizer N requirements are estimated by a combination of infield measurements, models of crop N uptake, and soil/crop residue mineralization. The system also helps growers maintain records of irrigation schedules and nitrogen fertilizer applications on multiple fields and allows users from the same farming operations to view and share data. CropManage was originally developed by UC Cooperative Extension and is currently free to use. Access at cropmanage.ucanr.edu

OVERVIEW OF TWO DECISION-SUPPORT SYSTEMS FOR VITICULTURE

What it does:

- Automates weather-based irrigation scheduling.
- Science-based algorithms provide site-specific recommendations for irrigation and nitrogen management based on soil type, climate, crop type, and crop development stage.
- Maintains records on water and nutrient management to support regulatory compliance.
- Includes optional links for import of OpenET data.

Vineyard version recently released:

- Cover Crop
- Deficit Irrigation
- Preliminary Nutrient Model

MANAGING POTASSIUM IN VINEYARDS

Matthew Fidelibus
Department of Viticulture and Enology | University of California, Davis

Matthew Fidelibus is an Extension Specialist in the Department of Viticulture & Enology at UC Davis. An internationally recognized viticulturist, his research program seeks to improve the yield and quality of raisin, table, and wine grapes through applied physiological research on rootstock and scion selections. Recent research has focused on, mineral nutrition, trellis and canopy management, and the use of plant growth regulators. Currently he is working to develop nitrogen and potassium budgets, and refine nitrogen fertilization guidelines, for table grapes. He is also testing trellis systems and management practices to optimize yield, quality, and mechanization potential for dry-on-vine raisin production.

Fidelibus received his B.S. in Biology from San Diego State University, his M.S. in Botany from Arizona State University, and his Ph.D. from the University of Florida. He joined the Department of Viticulture and Enology in 2002, and is located at the Kearney Agricultural Center, in Parlier, CA.

Fidelibus maintains an active extension program, and in 2015 was honored by the American Society of Enology and Viticulture for distinction in extension. In 2011 the Plant Growth Regulation Society of America awarded him the Young Scientist Award. He has given invited presentations on raisin, table, and wine grape production to grape grower groups throughout California in other western states, and in Argentina, Chile, India, and Peru. He has served as an associate editor of several academic journals in viticulture and plant science.

Potassium in Soil

Potassium (K) is an essential nutrient that fulfills critical functions including enzyme activation, osmotic adjustment, turgor generation, cell expansion, regulation of membrane electric potential, and pH homeostasis (Ragel et al., 2019). Large quantities of K are needed, so it is considered a "macronutrient". Potassium is one of the most abundant elements on earth, and most soils contain 0.5 to 2.5% K, equivalent to 20,000 to 100,000 lbs in an acre-foot of soil (Peacock, 1999), depending on the parent material. Potassium feldspars and muscovite micas are rich in K compared to olivines, pyrozenes, and amphiboles (Peacock, 2019). However, most of the K in soils exists as a structural component of primary and secondary minerals, or fixed in a lattice of clay minerals (such as mica, smectite, and vermiculite), and is not readily available to plants. A relatively small percentage of soil K is present as an ion, adsorbed and exchangeable at the surface of soil colloids, or as a solute of the soil solution.

Potassium ions diffuse through the soil via films of water surrounding soil particles. Diffusion is a relatively slow process, and rapidly growing vines can deplete K in the soil solution surrounding roots. Drying soil also reduces plant-available K, as the thickness of the water films around soil particles is reduced, which thereby increases the diffusion path lengths. Moreover, drying increases K fixation in soils, further restricting K availability to plant roots.

Potassium Uptake and Distribution in the Vine

Potassium absorbed from the soil is sent to leaves via xylem. In leaves, K+ is loaded into phloem for transport to other parts of the plants as needed, including the roots. This cycle distributes K to the plant tissues that need it and provides feedback to the roots on plant demand for K+. In grapevines, most of the annual uptake of K occurs between budbreak and veraison, particularly during the period between fruit set and veraison (Conradie, 2004). Before bloom, most of the K is sent to stems and leaves. After bloom, the fruit develops a strong demand for K, and after veraison, fruit demand for K may exceed the roots' uptake of K from the soil. Conradie (2004) estimated that 50% of the K needed by ripening fruit may be translocated from other organs, including roots, trunk, leaves, and stems.

K Deficiency Symptoms

The translocation of K from the leaves may result in K deficiency symptoms, which are typically first noticed in mid-summer, on leaves in the middle of a shoot. Potassium-deficient leaf blades develop a glossy appearance, bronze discoloration, and chlorotic (yellow) leaf margins, with an indistinct transition to the greener center of the blade. The leaf margin may become red or purple colored in red or black varieties, respectively. Leaf blades with severe deficiencies will also become "cupped" as the margins dry out and curl upward or downward.

Shoot growth on K-deficient vines is reduced, and leaf fall may be premature. Potassium-deficient vines may have fewer, smaller, and tighter clusters, with unevenly colored and smaller berries (Peacock, 1999). Tissue analysis is useful for monitoring the K status of vines. Bloom-time petiole samples collected from opposite a cluster should have K levels >1.5%; values between 1% and 1.5% are considered marginal and should be retested at veraison, at which time petioles from recently expanded leaves should have >0.8% K. Vines with particularly high crops should also be retested at veraison.

Potassium ions diffuse through the soil via films of water surrounding soil particles. Diffusion is a relatively slow process, and rapidly growing vines can deplete K in the soil solution surrounding roots. Drying soil also reduces plant-available K, as the thickness of the water films around soil particles is reduced, which thereby increases the diffusion path lengths. Moreover, drying increases K fixation in soils, further restricting K availability to plant roots.

Managing K in the Vineyard

Table grapes in San Joaquin Valley accumulated between 150 and 330 lbs of K per acre per year in their annual growth (leaves, stems, and fruit), with 55 to 65% of that allocated to clusters of grapes (Table 1). The K in a ton of table grapes ranged from 2.64 to 5.21 lbs, depending on the variety. Replacing the K in harvested fruit could be considered a maintenance application, though additional K is likely needed as applications are not 100% effective, and some applied K could be fixed in some soils.

However, some K fertilizer studies have shown no response to K applications, even in K-fixing soils. Determining the K needed to correct or prevent K deficiency is complicated by variables that affect K uptake, including soil type, depth, moisture content, rootstock genotype, and vine age. For example, deficit irrigation and drought can induce K deficiency, especially in K-fixing soils. Rootstocks with *V. berlandieri* heritage, including 1103P, do not take up K as readily as rootstocks derived from *V. champinii*, such as Freedom and Harmony. The smaller root system of younger vines might make them more susceptible to K deficiency.

Nitrogen, magnesium (Mg), and calcium (Ca) fertilizers can also affect K uptake. For example, table grapes subjected to sustained (multiple seasons) nitrogen (N) fertilizer regimes sometimes accumulated less K in leaves, stems, and clusters (Table 2), although the same N treatments applied for a single season did not affect K uptake (data not shown). In general, levels of K and N are closely related in most plants. Application of K without sufficient N may lead to decreased N content. Nitrate tends to promote K accumulation, whereas ammonium may interfere with the diffusion of K from clay lattice and compete with K for uptake by roots.

The relative presence of K, Ca, and Mg influences the concentration of each individual cation within the plant. Potassium usually has a greater depressing effect on Ca and Mg than does Ca or Mg on K, and Mg has a greater depressing effect on K than Ca. However, Ca appears to be less antagonistic to Mg than to K (Mills and Jones, 1996). Total cation amounts tend to increase as lime is added to the soil, possibly due to the replacement of H+ cation on the exchange complex with mostly Ca when high-Ca content lime is applied, or when both Ca and Mg are increased, if dolomitic lime is used. Total cations tend to decrease if either K or Mg is deficient. Despite the interactions between K and Mg plus Ca, critical values are not usually seriously affected unless the ratio of one of the elements to the other is very wide.

Fertilizer Practice

In furrow-irrigated vineyards, K requires deep placement in a concentrated band close to the vine (Christensen and Peacock, 2000). Application in winter will facilitate the movement of the fertilizer into the root zone. Growers often blend K with compost which helps keep the fertilizer in a desirable location, especially on sandy soils where it could be leached. Fertigation is more efficient than banded applications, enabling lower rates to be used, especially in K-fixing soils. According to Conradie (2004), vines begin to take up K from the soil within a few weeks after budbreak, so K fertilization could begin in early spring. After veraison, the rate of K uptake from the soil decreased, so he recommended K fertilization conclude by veraison. He also suggested that ceasing K fertilization at veraison might help prevent excess K in fruit. Growers in the SJV commonly "spoon feed" K through the drip system, applying relatively small amounts (10 to 13 lbs K/acre) weekly, for 5 to 10 weeks before veraison (Peacock, 2004). However, in heavier soils, K is not substantially leached below the root zone under drip irrigation, and a single application of K may be just as efficient as multiple applications (Peacock, 2004).

Foliar application of KNO3 had few or no effects on grapevines, possibly because of the low rate used (0.5%); higher rates caused phytotoxicity (Christensen, 2004). However, foliar applications of 0.5% K2SO4 or KH2PO4 were found to increase anthocyanin content of 'Kyoho' (Wu et al., 2021), and 'Cabernet Sauvignon' grape berry skins (Zhao et al., 2023). Obenland et al. (2015) found that foliar applications of K salts, including potassium sorbate, potassium bicarbonate, and glycine-complexed potassium, increased berry soluble solids by reducing berry weight due to dehydration. Foliar K applications could increase berry and wine pH, which might be undesirable.

References

Christensen, L.P., and W.L. Peacock. 2000. Mineral nutrition and fertilization. In: Raisin Production Manual. University of California Division of Agricultural and Natural Resources Publication 3393, Oakland, CA. pp. 102-114.

Conradie, W.J., 2004. Partitioning of mineral nutrients and timing of fertilizer applications for optimum efficiency. In: Christensen, L.P., Smart, D.R. (Eds.). Proceedings of the Soil Environment and Vine Mineral Nutrition Symposium. American Society for Enology and Viticulture, Davis, CA. pp. 69-81.

Mills, H.A., and J.B. Jones Jr. 1996. Plant Analysis Handbook II. Micromacro Publishing, Athens, GA. P. 21-22.

Obenland, D., E. Feliziani, S. Zhu, X. Zhao, D.A. Margosan, F. Mlikota Gabler, S. Van Zyl, G. Romanazzi, J.L. Smilanick, D. Beno-Moualem, T. Kaplunov, and A. Lichter. 2015. Potassium application after veraison increases soluble solids by enhancing berry water loss. Scientia Horticulturae 187:58-64.

Peacock, B., 1999. Potassium in soils and grapevine nutrition. University of California Cooperative Extension Tulare County, Publication NG9-99.

Peacock, W.L., 2004. Fertigating drip-irrigated vineyards with macro- and micronutrients. In: Christensen, L.P., Smart, D.R. (Ed.). Proceedings of the Soil Environment and Vine Mineral Nutrition Symposium. American Society for Enology and Viticulture, Davis, CA. pp. 129-133.

Ragel P., Raddatz N., Leidi E. O., Quintero F. J., Pardo J. M. (2019). Regulation of K nutrition in plants. Front. Plant Sci. 10. doi: 10.3389/fpls.2019.00281

Wu, L., L. Pengcheng, J. Haifeng, F. O. Philip, X. Bao, F. Zhao, B. Zhao, J. Feng, K. Yun. 2021. The effect of foliar application of K2SO4 or KH2PO4 on skin color of 'Kyoho' grape. Agronomy 11(11), 2361.

Zhao, T., S. Xie, and Z. Zhang. 2023. Effects of foliar-sprayed potassium dihydrogen phosphate on accumulation of flavonoids in Cabernet Sauvignon (Vitis vinifera L.). Journal of the Science of Food and Agriculture. Https://doi.org/10.1002/jsfa.12552

Table 1. The effect of cultivar on potassium (K) metrics at harvest averaged across N fertilizer treatments. Old refers to vines receiving the N treatments for two years (Old) and new refers to vines receiving N treatments for a single growing season (New). Total K at harvest is the sum of K in the leaves, stems and clusters*.

	Variety						
Fruit Parameters	Scarlet Royal (Old)	Scarlet Royal (New)	Crimson Seedless (Old)	Crimson Seedless (New)	Flame Seedless	Princess	Autumn King
Total K at harvest (g/vine*)	147	140	155	163	96.9	125.2	207.0
Total K at harvest (kg/ha)	263	251	174	183	173.6	224.4	370.9
Total K at harvest (lbs./acre)	234	223	155	163	154.6	199.7	330.2
Fruit K (% dry wt.)	1.11	1.30	0.85	0.87	1.25	1.03	1.51
Fruit K (g/vine)	77.7	79.4	93.6	105.6	62.8	36.3	121.8
Fruit K (kg/ha)	139	142	105	118	113	65	218
Fruit K (lbs./acre)	124	127	94	106	100	58	194
Fruit K (kg/t)	1.51	1.81	1.71	1.74	1.91	1.32	2.61
Fruit K (lbs./t)	3.01	3.63	3.45	3.49	3.84	2.64	5.21

Table 2. The effect of fertilizer amount and growth stage (bloom, veraison, and harvest) on the concentration of K in leaves, stems and clusters of Scarlet Royal and Crimson Seedless table grapes receiving different N treatments for two years.

Scarlet Royal		--------- Annual N Application Amount (g/vine)-----------		
Organ	Growth Stage	0	31.3	78.3
		--------------- Total **K** (% dry weight) ---------------		
Leaves	Bloom	1.33 a	1.04 b	1.18 ab
	Veraison	1.37 a	1.25 ab	1.17 b
	Harvest	1.09 a	1.00 ab	0.88 b
Stems	Bloom	1.84	1.81	1.71
	Veraison	1.34 a	1.12 b	1.17 ab
	Harvest	0.99	0.95	0.92
Clusters	Bloom	2.87 a	2.75 ab	2.67 b
	Veraison	1.52	1.49	1.47
	Harvest	1.18 a	1.11 ab	1.05 b

Crimson Seedless		--------- Annual N Application Amount (g/vine)-----------		
Organ	Growth Stage	0	42.3	105.8
		--------------- Total **K** (% dry weight) ---------------		
Leaves	Bloom	1.24 a	1.04 b	1.04 b
	Veraison[a]	1.22	1.16	1.14
	Harvest	1.00	0.89	0.79
Stems	Bloom	1.63	1.54	1.50
	Veraison	1.09	1.07	0.98
	Harvest	0.74 a	0.72 ab	0.68 b
Clusters	Bloom[a]	2.26 a	2.17 ab	1.94 b
	Veraison	1.22	1.16	1.14
	Harvest	0.88 a	0.84 ab	0.81 b

a.There was also a significant interaction of fertilizer amount and timing on the values in this row.

REPLACING THE ROOTSTOCK 'FREEDOM'

Other Rootstock Options for the San Joaquin Valley

Karl Lund, PhD, Viticulture Farm Advisor, Merced & Mariposa Counties, UCCE

Karl Lund is the University of California Viticulture Advisor stationed in Madera and covering Madera, Merced, and Mariposa Counties. His primary research efforts in his current role are looking at rootstock adaptation and mechanical vineyard management. He has worked for the past 5 years to evaluate 7 new nematode-resistant rootstocks for use in high-production San Joaquin Valley vineyards. He is also working to trial rootstocks for the lower-quality irrigation water found on the west side of the San Joaquin Valley. His work with mechanical vineyard management is looking at adapting new canopy management equipment to the high productivity needs of the San Joaquin Valley. Karl earned his Ph.D. from UC Davis where he worked in the laboratory of Dr. Andy Walker. Karl's Ph.D. work identified new feeding types of phylloxera and tested wild grape species, as well as current rootstocks, for resistance to the new types of phylloxera.

The emergence of Sudden Vine Collapse has brought into doubt the future functionality of the rootstock Freedom. While the exact mechanism of vine death during Sudden Vine Collapse is still being studied, a few items have emerged as important. Two of those items are infection with the grapevine leafroll-associated virus and the use of virus-sensitive rootstocks, with the rootstock Freedom being one of the most virus-sensitive rootstocks. While our understanding of Sudden Vine Collapse is still evolving, with the current knowledge, it is risky to use the rootstock Freedom in areas that have leafroll virus. Data collected in 2022 by Chris Chen show that Freedom is the second most popular rootstock accounting for 25% of recent California plantings. Much of the usage of Freedom is concentrated in the San Joaquin Valley, making this issue of major concern to those of us growing grapevines here. If Freedom is no longer an option for San Joaquin Valley grape growers, then what other options are available?

For the San Joaquin Valley, yield is an essential characteristic. The rootstock used in a vineyard can have a major effect on the vigor of that vineyard. While vigor and yield are not the same, higher vigor rootstocks give growers the best opportunity for higher yields. There are two sets of new rootstocks available to growers, which I have been trialing at two sites within the San Joaquin Valley for the last six growing seasons. These rootstocks were all developed for nematode resistance, but they could also possess traits that make them a possible replacement option for Freedom.

Figure 1. Shows the vigor of twenty rootstocks separated into six vigor categories. With the current concerns over the rootstock Freedom, and previous issues that led to the rootstock Harmony being removed from common use, we have now effectively lost the "high vigor" category of rootstocks from use. This requires growers to use "very high vigor" rootstocks with the chance of having overly vigorous growth. Or using a "medium-high vigor" rootstock, and possibly missing their harvest objective. Or are there rootstocks that weren't available when this figure was first created?

Figure 1 Rootstock Vigor adapted from Dr. Walker's lecture notes. Vigor imparted by common rootstocks to grafted scions.

These new rootstocks are the root-knot nematode-resistant RS3 and RS9, and the Grapes Resistant to Nematodes GRN1, GRN2, GRN3, GRN4, and GRN5 with broad nematode resistance. Table 1 shows the ability of these new rootstocks along with several common rootstocks to support the reproduction of several distinct types of nematodes. So where would these new rootstocks fit within the vigor levels?

Before getting into the data, I have collected it is important to talk about the two vineyard sites I have been working at. Both vineyards have a single-high wire trellis system and are fully mechanized. The first vineyard site is located just outside of the city of Madera. It was planted in 2009 with an eight-foot vine x ten-foot row spacing with Petite Verdot as the scion. This site has both RS rootstock, and all 5 GRN rootstocks, as well as Freedom and 1103P as standard controls. Each replicate in this vineyard consists of an 8-vine panel that was replicated 5 times, for a total of 40 of each rootstock across the trial. The second vineyard site is located a bit north of the city of Merced. It was planted in the fall of 2016 on a five-foot vine x eleven-foot row spacing with Malbec as the scion. This site has both RS rootstocks, but only has GRN2, GRN3, and GRN4 rootstocks, and has 1103P as the only standard control. While this trial has fewer rootstocks, each replicate consists of an entire row of 388 vines with 4 replicates per rootstock. That means at the Merced site there are 1552 of each rootstock at this trial. This means that the Madera site has a larger variety of rootstocks, while the Merced site has a larger number of vines from which to collect data.

One of the main traits I have been following for these rootstocks is canopy size. I have been tracking canopy size with a Paso Panel. To do this, I slide a solar panel (Paso Panel) beneath the canopy within an hour of solar noon (12 PM - 2 PM) and measure the number of amps the solar panel produces. This result can then be compared to a reading taken in full sun to calculate the percentage of the solar panel that is shaded by the canopy. While this data can be used to calculate the vineyard's crop coefficient, in this case, we just want to know which rootstock is producing the largest canopy. The data from the Madera site in 2023 can be found in Figure 2. We can see that by early May the rootstocks have split into two distinct groups. Freedom, GRN2, GRN3, GRN4, and GRN5 all make up the larger canopy group, while 1103P, GRN1, RS3, and RS9 make up the smaller canopy group. Overall 1103P does not perform well at the Madera site, so this is an underrepresentation of how 1103P performs. The 2023 data is very consistent with all the years of data collection at this site. Overall, at this site, Freedom and GRN2 always have the largest canopies every year. hanging out at the bottom of the larger canopy group until it catches up in mid-June. RS3 always leads the smaller canopy group in Madera, with GRN1, RS9, and the underperforming 1103P bringing up the bottom.

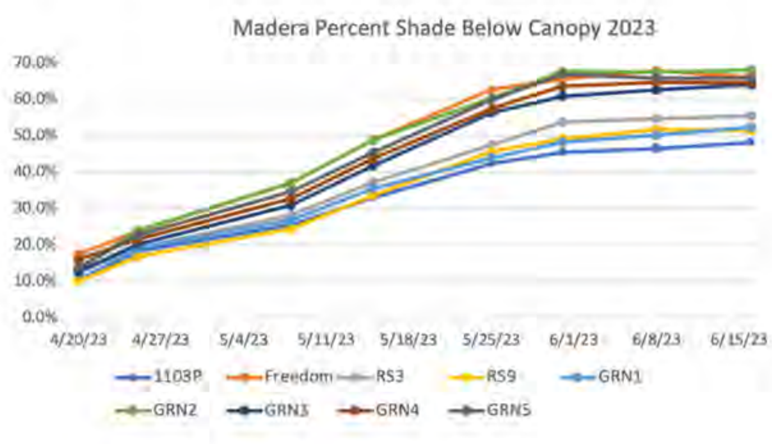


Figure 2. Percent Shade below canopy as measured by Paso Panel. Data was collected at the Madera rootstock trial in 2023.

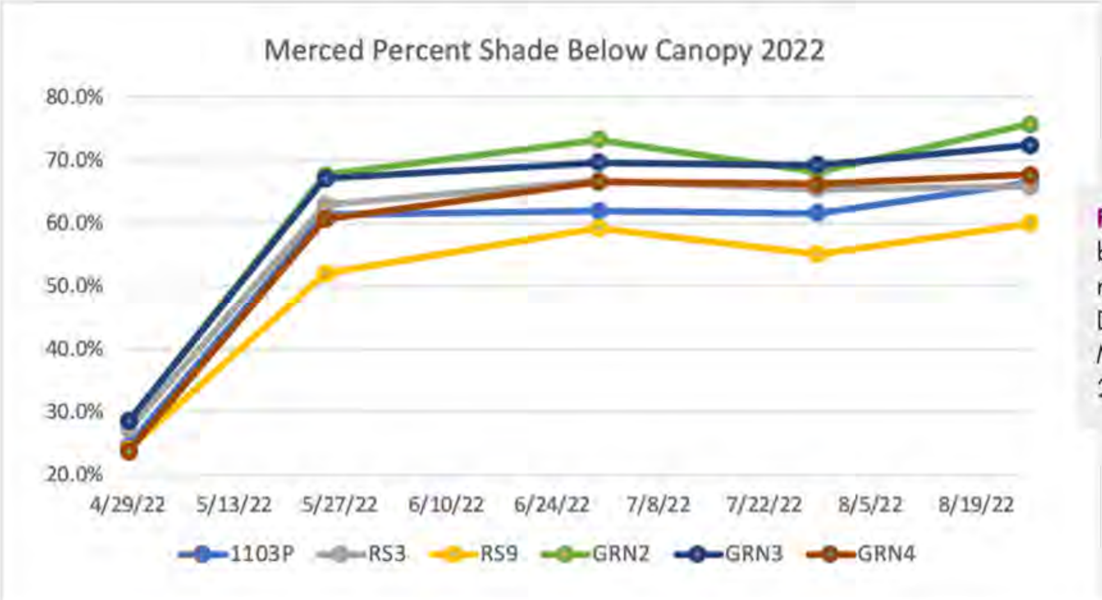


Figure 3. Percent Shade below canopy as measured by Paso Panel. Data was collected at the Merced rootstock trial in 2022.

The Merced trial site tells a similar story, but with 1103P performing more to expectations. The data collected in 2022 from the Merced trial is shown in Figure 3. The rootstocks here don't separate into two groups as noticeably, but the general difference remains. GRN2 again is one of the top canopies, with GRN3 being a close second (or even surpassing it at one data collection point). GRN4, RS3, and 1103P now form a moderate canopy-size group that is a half-step behind GRN2 and GRN3. While RS9 consistently has the smallest canopy.

If the results from both sites are combined for canopy size. GRN2 and GRN3 are consistently among the largest canopies at both sites, along with Freedom at the Madera site. GRN4 at both sites and GRN5 in Madera are close to but slightly smaller than GRN2 (and Freedom), but also consistently larger than 1103P. RS3 also has a canopy that is at least as large as 1103P, however depending on site it can be similar in size to GRN4 (Merced), or significantly smaller (Madera). RS9 at both sites and GRN1 in Madera have smaller canopies. Both RS9 and GRN1 outperform 1103P in Madera. However, considering how poorly 1103P performs in Madera, I expect that they would overall be smaller in locations where 1103P performs normally.

How do the yields compare to canopy size/vigor? In Madera, the yields from each rootstock break into 5 separate groups. Freedom stands alone with the largest yield at over nineteen tons per acre. GRN2 and GRN3 are in the next group with approximately sixteen tons per acre.GRN1, GRN4, and GRN5 are in the third group with between fourteen and fifteen tons per acre. RS3 is next and is between thirteen and fourteen tons per acre, while RS9 and 1103P are in the bottom group with below twelve tons per acre. Overall, this shows a general matching between canopy size and yield at the Madera site. The five members of the large canopy group are among the six highest yielding.

REPLACING THE ROOTSTOCK 'FREEDOM'

Other Rootstock Options for the San Joaquin Valley

The three smallest yielding rootstocks all come from the small canopy group.The one outlier is GRN1, which is among the small canopy group, but is in the middle yield group, and overall had the fourth-highest yield in Madera. The picture gets more complicated when looking at the yield results from Merced. The vineyard had not yet reached maturity when the last harvest data was collected and was suffering from the results of the delayed spring growth seen across the state back in 2021. The data did not separate into groups due to the large amount of variability seen across the research block. Overall GRN3 had the highest yield followed by RS3. RS9, followed closely by GRN4 and 1103P then followed, while GRN2 had the lowest yield. This is a vastly different picture in general, but a couple of constants do show through. GRN3 is again at the top of the yield ladder, while RS3 and GRN4 outproduced 1103P. However, the vast shift in production of RS9 and GRN2 is perplexing. Should we believe the yield data from Madera or Merced? Unfortunately, the vineyard where the research trial is located was top-grafted at the beginning of 2023. I won't be able to collect more data from that vineyard until 2025.

To help solve this mystery it is helpful to check in with other trials run with these rootstocks. George Zhaung working on wine grapes in Fresno County found that GRN2 took longer to fully establish and produce larger yields. Tian Tian working on table grapes in Kern County also found that GRN2 took a couple extra years to establish itself, with low yields in the beginning before climbing to become a high-yielding rootstock. Her work also identified GRN2, GRN3, and 1103P as all belonging to the highest-yielding group of rootstocks. With Freedom, RS3, and GRN4 being intermediate producers. Lastly, Rhonda Smith working on wine grapes in Sonoma County again found that GRN2 had the largest vine (canopies). She also found that RS3 and RS9 had the smallest canopies and low yields.

Bringing this all back together for vigor and yield. GRN2 and GRN3 have consistently large canopies at both sites and continuously rank with Freedom, so I have put them into the "High Vigor" category (figure 4). For yield, GRN3 is consistently in the higher-yielding category.GRN2 is also consistently higher yielding, but it does appear to take a couple of extra years to fully establish itself to reach its yield potential. However, it is underperforming in Merced, beyond just getting established. I placed GRN4 at the top of the "Medium-High Vigor" category, with RS3 being placed just above 1103P in the same category. he data from both sites does show that these rootstocks are equal in canopy size and yield potential to 1103P.

Figure 4 Rootstock Vigor adapted from Dr. Walker's lecture notes and updated by Dr. Karl Lund. Vigor imparted by common rootstocks to grafted scions.

GRN4 is placed at the top of the "Medium-High Vigor" category due to its oversized canopy at the Madera site. RS9 was placed at the bottom of the "Medium Vigor" category as it is consistently smaller than 1103P. RS9 does produce well in Merced, but that is not consistent across other research sites. (GRN1 and GRN5 were left out of Figure 4 as I only have data from one research site, and no corroborating data from fellow researchers.)

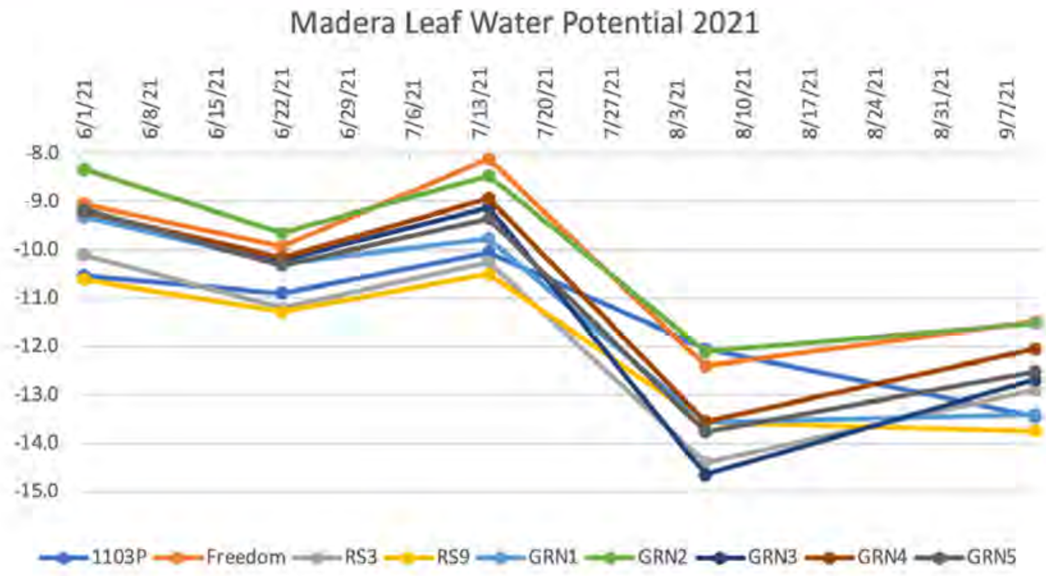
Another important characteristic needed by San Joaquin Valley growers is drought tolerance. Table 2 is taken from Wine Grape Varieties in California and gives a general list of drought tolerance by rootstock. Of course, the definition of drought tolerance varies from list to list depending on what you are evaluating. As for my research, I have been using two definitions. The first is that a drought-tolerant rootstock maintains lower levels of water stress (as measured by midday leaf water potential) throughout the growing season.

Rootstock	Drought Tolerance
110R	High
140Ru	High
St. George	High in deep soil
Salt Creek (Ramsey)	Med-high
1103P	Med-high
Dogridge	Med
Freedom	Med
5BB	Med
St. George	Low med in shallow soil
039-16	Low

A second definition I use is that a drought-tolerant rootstock maintains lower levels of water stress (as measured by midday leaf water potential) during water-stressful events. These would be events that cause a higher level of water stress than typically seen throughout the rest of the growing season.These could be purposeful or accidental events where irrigation is reduced below the vineyard's evapotranspiration. Or events like heatwaves that cause higher levels of water use naturally.

In terms of general levels of water stress across the season. Rootstock-based levels of water stress across the growing seasons in Madera gave consistent results across three years (2020 - 2022), with the data from 2021 displayed in Figure 4. Freedom and GRN2 maintain the lowest level of water stress across the entire growing season. On the other side, RS3, RS9, and 1103P spend most of their time with a higher level of water stress. GRN3, GRN4, and GRN5 spend most of their time with lower levels of water stress, sometimes grouping with Freedom and GRN2, and sometimes splitting into a moderate water stress group. GRN1 begins the season in the low to moderate water stress group, however, during the middle of the season begins to drop into the moderate and eventually the high-water stress group.

The interesting results come from late July and early August when the vineyard management team uses post veraison dry down to increase plant stress. During this dry down, all vines see increased water stress. GRN2 and Freedom stay in the low-stress group and are joined by 1103P.On the surface, this appears to be a good result for 1103P, however, it is due to canopy damage. During the dry-down, the canopy of vines on 1103P burns, leaving the outer layer of the canopy damaged. After the canopy recovers 1103P drops back down into the high-water stress category. GRN4 and GRN5 are joined by RS9 and GRN1 in the moderate stress category. RS9 does see increased water stress during the dry down, however, due to its small canopy its drop isn't as severe. GRN1 is similar as it has already moved into the high-water stress category before the dry down starts, but the moderate stress category rootstocks catch back up to it during the dry down. RS3 and GRN3 now make up the high-water stress group. While RS3 has been here the entire time, the addition of GRN3 is interesting.



During water-stressful situations, GRN3 crashes from being in the low to moderate water-stress group to being one of the most water-stressed rootstocks. This is both at the Madera site, during purposeful water stressful situations, and at the Merced site, during heatwaves and other natural water stressful situations. After irrigation levels return to normal GRN3 does recover quickly. By the next data collection point, it is always back in the moderate water stress group once the cause of the water stress has been removed. Generally, this doesn't cause any damage to the canopy, and only slightly slows down growth. The only time I witnessed damage from this effect was when the irrigation system at the Merced trial failed. During the repairs, GRN3 did get to the point that the canopy lost most of its shoot tips. Once the irrigation system was repaired, the vines quickly recovered and lateral growth began allowing the canopy to continue growing.

Rootstock	Regular Effect	Stressful Event
Freedom	Low	Low
GRN2	Low	Low
GRN4	Low-Moderate	Low-Moderate
GRN5	Low-Moderate	Low-Moderate
GRN3	Low-Moderate	High
1103P	Moderate	Moderate
RS3	High	Moderate-High
RS9	High	Moderate-High

Table 3 Water Stress effects of different rootstocks. The effect different rootstocks have on water stress during Regular well-watered conditions, and Stressful events when irrigation does not keep up with water use.

The results from the Merced trial are similar to the Madera trial.The only major difference is that 1103P handles itself much better at this trial. GRN2, again, maintains the lowest level of water stress throughout the entire season. GRN3, GRN4, and 1103P form a middle-stress group for most of the growing season.Leaving RS3 and RS9 as the high-stress group. During high-stress conditions, GRN3 still becomes extremely water stressed just as at the Madera trial. At the Merced trial during stressful situations RS3 and RS9 switch places. RS3 steps up into the moderate water-stressed group, while RS9 stays in the high water-stressed group.

Rootstock	Salinity Tolerance
Salt Creek (Ramsey)	High
140Ru	Medium-High
St. George	Medium-High
Dogridge	Medium-High
110R	Medium
5BB	Medium
1103P	Medium
039-16	Low-Medium
Freedom	Low-Medium

Table 4 Salinity (E.C.) Tolerance imparted by different rootstocks. Adapted from Wine Grape Varieties in California, UC ANR Publication Number 3419.

A final prominent issue in parts of the San Joaquin Valley is salt (E.C.) tolerance. This is especially true along the western side of the central and southern San Joaquin Valley. I have had to deal with salinity issues in western Merced and Madera Counties. At the same time, George Zhuang and I are running a salt (E.C.) tolerance and drought trial in western Fresno County. This trial just had its first harvest in 2023, and data is still being analyzed. A list of salinity tolerances for common rootstocks can be found in Table 4.Salt Creek (Ramsey) is considered to have high tolerance, while Freedom is considered to have low medium tolerance.In western Merced and Madera Counties, the issues I have had to deal with included Freedom inability to handle the local growing conditions.

Both the Madera and Merced trials do not include conditions that could be considered to have high salinity. That being said nutrient profiles were collected at both locations. For grapevines chloride (Cl) is the principal element when looking at salt tolerance. Data collected from both Madera and Merced show that 1103P does have good chloride exclusion (Figure 5). Freedom also has the highest level of uptake showing why it has only a low-medium salinity tolerance. GRN2, GRN3, GRN4, and GRN5 also have higher levels of chloride uptake but are still below Freedom.

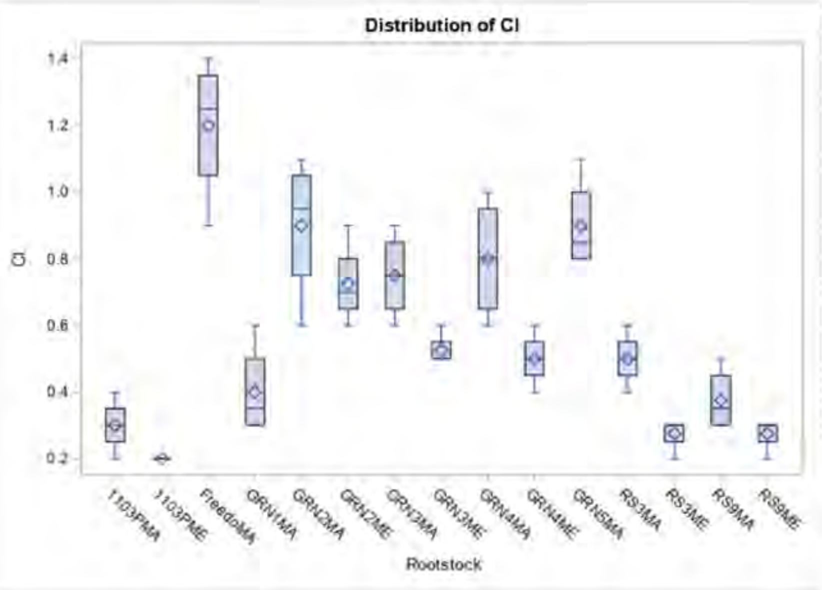


Figure 5 Veraison Petiole Chloride Concentrations from Madera and Merced.

GRN1, RS3, and RS9 also have lower levels of chloride uptake, although not as low as 1103P. Looking at both the new data for the GRN and RS rootstocks, along with the information available for common rootstocks. What other options are available for growers in the San Joaquin Valley if they want to avoid using Freedom? The rootstocks will be listed in order of expected vigor from highest vigor to lowest vigor. While Salt Creek (Ramsey) is not part of the trials discussed in this article, I do use it at two additional trial sites.

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Salt Creek does not produce a strong canopy in its first few seasons but puts a lot of growth during those early seasons into its root system. It wasn't until the vineyard's 4th leaf that the vines took off.GRN2 has high vigor, but especially during development can have low yields (big canopy, but yields have to wait until the vines are fully established). It also maintains low water stress throughout the season, as well as during high water stress events such as heatwaves. GRN3 has high vigor and consistently high yields. GRN3 has low to moderate water stress under full irrigation, however, during water deficit events will see rapid high levels of water stress. If you have a situation where irrigation water may not be available during heatwaves, or if your irrigation system isn't dependable, then you may want to avoid this rootstock.On the other side, if you want to use water stress to achieve production goals this would be a good rootstock to consider.

Genotype	M. incognita Race 3	M. javanica	Meloidogyne Type Harmony A&C	M. chitwoodi	P. vulnus	T. semipenetrans	Para. hamatus	M. xenoplax	X. americanum	X. index
Nematode Type	Root-knot Nematode	Root-knot Nematode	Root-knot Nematode	Root-knot Nematode	Lesion Nematode	Citrus Nematode	Pin Nematode	Ring Nematode	Dagger Nematode	Dagger Nematode
Ramsey	Very Small	Very Small	Large	Large	Medium	Medium	Large	Large	Large	Small
Freedom	Very Small	Very Small	Large	Large	Medium	Large	Small	Medium	Medium	Very Small
140 Ruggeri			Small		Large		Medium	Large		Large
VR O39-16	Large	Large	Large		Small	Large	Small	Very Small	Small	Very Small
1103 Paulsen			Large		Medium		Large	Large		Large
110 Richter			Small		Large		Large	Large		Large
RS-3	Very Small	Very Small	Small	Small	Small		Large	Large		Large
RS-9	Very Small	Very Small	Very Small	Very Small	Medium		Large	Large		Large
UCD GRN1	Very Small		Very Small		Small	Very Small	Small	Very Small		Very Small
UCD GRN2	Very Small		Very Small		Small	Medium	Small	Medium		Very Small
UCD GRN3	Very Small		Very Small		Small	Small	Small	Small		Very Small
UCD GRN4	Very Small		Very Small		Small	Small	Medium	Small		Very Small
UCD GRN5	Very Small		Very Small		Small	Small	Small	Very Small		Very Small

Table 1 nematode population size supported by different rootstocks adapted from Ferris, Zheng, & Walker 2012. Very Small <10% susceptible control (dark green), Small 10-30% susceptible control (light green), Medium 30-50% susceptible control (yellow), and Large >50% susceptible control (red).

SGRN4 has a moderately high level of vigor along with good yields at or above those achieved by 1103P. GRN4 also maintains a low to moderate level of water stress equal to or lower than 1103P.O39-16 has moderately high vigor, low drought tolerance, and low to moderate salinity tolerance. O39-16 can also suppress the symptoms of grapevine fanleaf virus, which I have been finding more often around the San Joaquin Valley. I have not been able to trial O39-16 within the San Joaquin Valley but have been happy with its performance in other regions. RS3 has moderately high vigor and yields at or above 1103P.

It maintains higher levels of water stress even when well-watered. RS3 is also reported to have the ability to suppress the symptoms of grapevine fanleaf virus. While I have not seen any published data to support these claims, the people who have reported this are well-respected researchers. 1103P has moderately high vigor, moderately high (although I would drop it down to moderate) drought tolerance, and moderate (which I would raise to moderately high) salinity tolerance. RS9 has only moderate vigor and is always water-stressed, even when well-watered. The canopy size is too small for single highwire trellising, leading to fruit burn issues.


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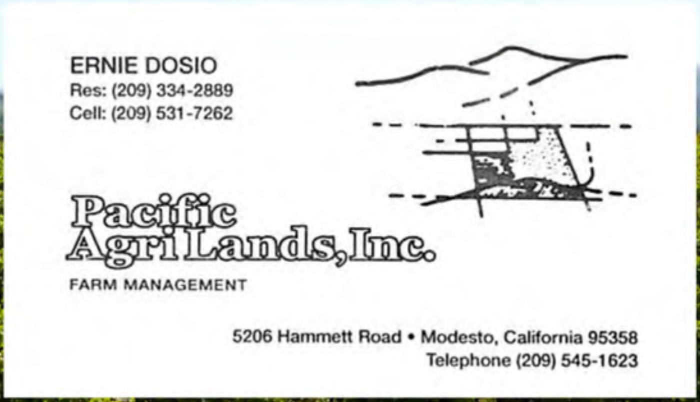
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WHY IT'S PARTICULARLY DIFFICULT TO PROTECT YOUR VINEYARD FROM MEALYBUGS & VIRUSES IN CALIFORNIA

Stephanie Bolton, PHD, Grower Research & Education Director, Lodi Winegrape Commission

Dr. Stephanie Bolton leads the Grower Research, Education, & Communications initiatives, plus the LODI RULES Sustainable Winegrowing Program, at the Lodi Winegrape Commission, an organization representing 750 growers farming around 90,000 acres of winegrapes. Stephanie brings to the table proven team organizational leadership, a high level of motivation and passion to discover both short- and long-term solutions for the farming families she adores, and an innate ability to creatively open communication channels between growers, scientists, and relative industry personnel. In 2023 she was selected as a Nuffield International Farming Scholar, a Wine Enthusiast Future 40 Honoree, and a Wine Business Monthly Industry Leader.

Today, most winegrowers are aware of the high risk for leafroll virus infection when there are mealybugs in their vineyard and/or in neighboring vineyards. Mealybugs and scale insects are vectors of (meaning they spread) leafroll virus and a group of viruses called vitiviruses (GVA, GVB, etc.). Leafroll virus reduces a vine's ability to photosynthesize, making it difficult or even impossible to ripen grapes in some cases and vintages. It can also lower yield which reduces the profitability of a vineyard. On several common rootstocks that are more sensitive to leafroll virus, a co-infection of leafroll and vitiviruses plus added stress (crop stress, water stress, trunk disease, etc.) can lead to a disease we named sudden vine collapse. Growers across California have painfully watched entire sections of their vineyards die off. Sudden vine collapse symptoms look like patches of dead and missing vines with vines showing stunted shoot growth on the edge of the death patch.

Figure 1: A cluster of vine mealybugs at various life stages on a grapevine shoot in Lodi. The tiny yellow insects are called crawlers, the larger white insects are adult females, and the cotton-looking parts are egg sacs. Photo taken with the help of a 15x hand lens by author.

Figure 2: Sudden Vine Collapse in a Lodi AVA vineyard. Note stunted growth, shriveled foliage and patch of death. Photo taken in Summer 2019 by author, when we were still testing potential causes and it was called "Mystery Vine Collapse." We now believe it is caused by a combination of leafroll virus, vitivirus, and additional stress on certain rootstocks, including but not limited to several of our common ones.

WHY IT'S PARTICULARLY DIFFICULT TO PROTECT YOUR VINEYARD FROM MEALYBUGS & VIRUSES IN CALIFORNIA

At the Lodi Winegrape Commission, we have intensely, holistically, and collaboratively studied our local vine mealybug and grapevine virus situation since 2002. We still have a lot to learn, and we work tirelessly to pass along our findings as we go because we believe in learning together and the power of teamwork in overcoming big challenges. Through many, many long conversations between growers, pest control advisors, nurseries, laboratories, scientists, industry, and others we have discovered the various options available for mealybug control, virus testing, and rogueing (grapevine removal). We gathered information from our local region, from California, and beyond and shared it in our red virus book, What Every Winegrower Should Know: Viruses (2020, Lodi Winegrape Commission).

Figure 3: The infamous collaboratively written "red virus book," *What Every Winegrower Should Know: Viruses* (2020, Lodi Winegrape Commission). Mealybug and rogueing flagging tape are still available from the Lodi Winegrape Commission, along with flash drive versions of the book.

Despite making significant strides towards understanding this issue and increasing our efforts in the vineyards, we realize that the battle to keep our vines healthy is far from over.

The great California mealybug and virus challenge is at the front of our minds, and the members of our Virus Focus Group continue to strategize and bring outside-the-box thinking in an effort to keep our farms sustainable. At parties you can inevitably find us in the corner somewhere engaged in a discussion about the best ant control (this happened at a graduation party - current theory is two applications of Esteem applied with a herd spreader). After a few glasses of wine, we have been known to act out vine mealybug parasitism by the Anagyrus wasp to new friends. Dr. Keith Striegler sends us articles every few months on the exemplary boll weevil eradication in cotton as inspiration. Mealybugs invade our nightmares. We dazzle fellow vacationers with our documentary-worthy story (thank you, sweet Irish woman on the Great Barrier Reef cruise). Charlie Starr IV twisted pheromone mating disruption onto my Jeep's side-view mirrors. In short, we are committed to finding a way out of this mess and at the same time, our friends and family are quite ready for new conversation topics.

WHY IT'S PARTICULARLY DIFFICULT TO PROTECT YOUR VINEYARD FROM MEALYBUGS & VIRUSES IN CALIFORNIA

Through these fascinating discussions and by visiting farms across the globe, I've come to realize that California has unique challenges around mealybugs and leafroll virus that are critical for us to understand:

1. Our main destructive mealybug species, the vine mealybug, spreads leafroll virus particularly well.

The vine mealybug has 5-7 generations (life cycles) per year. Some other regions have main mealybug species which aren't as proliferous. For example, the two main mealybug species of concern in New Zealand, citrophilus and obscure mealybugs, only have 3 generations, making their overall numbers lower. Our warmer winters are not helping our situation either, as insect generations mainly depend on temperature.

2. The synthetic plant protectant tools for mealybug IPM (integrated pest management) are becoming unavailable.

South Africa leads the world in their country's ability to control leafroll virus. The backbone of their program is a material called imidacloprid, a neonicotinoid whose use is now restricted in California.

Figure 4: It is important to either peel the wax off of nursery shipments before planting or ask the nursery to do so, since shipments of vines have been known to contain mealybugs underneath the wax (as shown above). Mealybugs are nearly impossible to eradicate in most commercial vineyards in California once they are present. Photo taken by local viticulturist.

3. Mealybugs and viruses are moving through our supply chain.

It is bad business but not illegal to sell vines carrying mealybugs or leafroll virus. As a state, we didn't establish the invasive vine mealybug as a quarantine pest early on though we should have (lesson learned - the spotted lanternfly is a quarantine pest). Growers are still unknowingly planting fields of vines infested with mealybugs and infected with leafroll virus. It's the responsibility of nurseries and growers to do their part to plant clean material. We can't state the importance of checking under the wax at the graft union for mealybugs and of doing an extra set of virus testing for leafroll and red blotch viruses (above and beyond the CDFA grapevine certification!) enough. New plantings with a problem then serve as a host for mealybugs and viruses to spread throughout the neighborhood and region. At this stage in our crisis, once mealybugs are present in a vineyard, they cannot be eradicated. Hopefully one day that will change. We hope that canine detection of mealybugs and viruses in nurseries and new vineyard plantings will help.

4. Most California vineyards have external crews, vehicles, and machinery moving through them.

Without a sanitation protocol in place, each time a crew, a vehicle, or a piece of equipment comes into your vineyard during the growing season, there is potential for them to bring in virus-infected mealybugs with them.

WHY IT'S PARTICULARLY DIFFICULT TO PROTECT YOUR VINEYARD FROM MEALYBUGS & VIRUSES IN CALIFORNIA

5. Many vineyards in California are very close to (within meters of) vineyards owned by someone else.

It's difficult to accept, but we can control very few things in life. One of the things we cannot control is what happens in our neighboring and regional vineyards that we do not manage. If there is a vineyard with mealybugs and leafroll virus upwind of yours, you are at greater risk to become infested and infected yourself. California has areas that look like patchwork quilts of vineyards with different owners. In Uruguay, for example, vineyards with different owners are much more spread apart with miles of natural areas between them.

Figure 5: Aerial view of New Zealand showing windbreak hedgerows between farms. Photo taken above Auckland by author during a Nuffield International Farming Scholarship tour.

6. There are fewer physical barriers around our vineyards than in other parts of the world.

As you drive through California you will find areas of the state where there are back-to-back vineyards for miles. We just mentioned Uruguay where farms are surrounded by wild, natural areas. In New Zealand, farms are bordered by windbreak hedgerows. Both scenarios offer a natural barrier which also provides habitat for beneficial insects. Our rate of infestation with mealybugs and infection with viruses is therefore much faster. Growers are telling us that they are seeing vine mealybugs in their new vineyard plantings as soon as the first three months. Crop rotation and farm diversification are becoming increasingly important as the disease risk increases along with the cost to establish a new vineyard.

Figure 6: Machine harvesters have great potential to spread vine mealybugs, both within a vineyard and between vineyards. Mealybug populations are at their annual peak during harvest. Photo taken by author.

7. We have a shortage of labor that drives mechanization.

Machine harvesting is a high-risk activity when it comes to mealybug and virus infections. Both the mealybug populations and the amount of leafroll virus present in a grapevine are at their peak during harvest. Imagine the spray of infected mealybugs that happens as a harvester moves down a row.

Does your custom harvester sanitize their equipment with a disinfectant before it enters your vineyard? We have the potential for another fast and furious harvest in 2023. Before it starts, have the conversation needed to understand what can be done to ensure sanitation of equipment.

8. Many of our vineyards have been under drought and/or crop stress.
A little stress is good for wine quality because the plant produces antioxidants in response to stress which improve anthocyanin production, increasing color and flavor in the grape berries. Too much stress, however, can have detrimental effects on plants just like it does in humans. California has recently experienced both a severe drought and an oversupply of winegrapes leading to low prices, encouraging high yields to keep vineyards in the ground (further exacerbating virus disease and our oversupply problem).

9. The majority of our vineyards are owned separately from their winery buyer.
If a winery owns virus-infected vineyards, they have a vested interest in cleaning them up to raise wine quality. They also have an inherent desire to protect their vineyards from vine mealybugs, and they understand the added cost in doing so. A significant portion of growers in California, however, sell their grapes to outside winery buyers. Caine Thompson, who helped lead a successful regional leafroll virus eradication program in Gimblett Gravels, told us that wineries play a key role in reducing virus infections. Once the wineries understand that grapevine viruses are an industry-wide problem (not a grower's problem), they can work with the growers to transition into cleaner vineyards over time. We do not have the winery buyers on board yet. Instead, too often we observe a winery cancel a contract with a grower whose virus infections are inhibiting ripening and offer a new planting contract at a price too low to ensure adequate mealybug and virus management.

10. Virus testing is particularly expensive and laboratories operate without oversight.
In South Africa, it costs about $5 USD to test a vine for leafroll virus. In the US, this may cost $75 plus the cost for overnight shipping. The virus testing laboratories have actually asked us (the Lodi Winegrape Commission) to help them ensure accurate testing by sending them blind samples and to help them get official accreditation for grapevine virus testing. Due to the hurdles around virus testing, many growers choose to simply not know which viruses their vineyards are infected with. By the time they test, it is usually a shocking surprise to see how many viruses exist in a single block.

Figure 7: A newly-implemented truck and person wash required for entry into a cattle feedlot in Indonesia. Photo taken by author during a Nuffield International Farming Scholarship tour.

11. Our farm biosecurity for vineyards is almost non-existent.
Between March to April this year, I traveled to Canada, New Zealand, Australia, Indonesia and Japan during a Nuffield International Farming Scholarship tour. Each time I entered a country I was asked if I had been on a farm...except for when I returned to the United States. Instead, the customs officer in San Francisco asked me if it was hot in Lodi, to which he got a thorough response about our cooling Delta breezes and large diurnal swing which creates an excellent climate for winegrapes. Indonesia had better biosecurity. Before we walked onto even a backyard farm with four cows, we dipped our boots into a sanitizing solution. We saw trucks and people get washed down before they entered a cattle feedlot (pictured above). This same ranch also had a separate, quarantined parking area for the motorcycles that the many, many employees rode into work (they planted 80 hectares of corn by hand there!). In Japan, we wore disposable booties in every field. We drove through tire washes in Australia's northern Tablelands where the banana industry is terrified of Panama disease tropical race 4.

12. Many of our vineyards are very large.
When a group of Italians visited us, they could not believe how long our rows of vines were. They exclaimed jokingly to each other that they would never make it to the celebratory beer at the end of a row during pruning. Even with a plethora of technology to help monitor our vineyards, it is still quite difficult to notice an early infestation of mealybugs or to map which vines are symptomatic for leafroll virus (remembering that for white grape varieties, this is nearly impossible) when a vineyard is over about 20 acres. In September 2020, I tested a new leafroll virus symptom app designed in New Zealand, where I was instructed to take photos of every vine in a row. My brand new iPhone shut itself down from overheating before I could finish the row.

Figure 8: Typical leafroll virus symptom of leaf reddening with green veins in a red winegrape variety. Photo taken by author.

13. There is a considerable amount of leafroll virus present in our vineyards across the state.
Without infected vines, the mealybug problem would not be so huge because the mealybugs would not have virus to spread. This is why rogueing, or removing infected vines, is so important. There are different theories floating around as to why leafroll is so widespread (AXR1 was hiding it, planting booms, etc.), but we can all agree that there is simply too much leafroll out there today.

WHY IT'S PARTICULARLY DIFFICULT TO PROTECT YOUR VINEYARD FROM MEALYBUGS & VIRUSES IN CALIFORNIA

Knowing these California-particular challenges will help us understand how to best protect the next generation of our vineyards. It is clear that we need better and earlier detection methods for vine mealybugs and leafroll virus, and we are hoping that canines can help us with that.

TEAM LED BY LODI WINEGRAPE COMMISSION AWARDED $400,000+ TO STUDY CANINE DETECTION OF MEALYBUGS & LEAFROLL VIRUS

A team led by the Lodi Winegrape Commission was awarded a $428,111 Department of Pesticide Regulation (DPR) research grant in 2023 to determine whether the robust olfactory senses of canines can detect vine mealybugs and leafroll virus in nurseries and commercial vineyards. The project combines the unique expertise of canine detection professionals, University of California scientists, and the Lodi Winegrape Commission.

Any threat to the viability of the California winegrape industry - valued at $57.6 billion in annual economic activity according to the California Association of Winegrape Growers - threatens our state's economy. Our canine detection project aligns well with our efforts to farm sustainably and practice prevention, the core principle of integrated pest management. The title of a Wired article by Spencer Ackerman (2010) showcases the massive untapped potential of canine detection, which we hope to bring more into agriculture: '$19 Billion Later, Pentagon's Best Bomb-Detector is a Dog.' Dogs are a farmer's best friend, so this is a fun approach to one of our biggest challenges.

Leafroll virus is the world's most destructive grapevine virus. The virus is vectored by the invasive vine mealybug that is spreading the virus at an alarming rate through nursery material, within vineyards, between neighboring vineyards, and across entire regions. Leafroll infections reduce yield and quality of winegrapes, decrease a vineyard's lifespan, contribute to sudden vine collapse, and make land less suitable for future plantings. Early detection of mealybugs and viruses, as is possible with canines, is critical to reducing pesticide use and fostering long-term sustainability of vineyards.

The project team includes Dr. Neil McRoberts (University of California, Davis), whose close working relationship with now-retired USDA scientist Dr. Tim Gottwald propelled the original project idea. Dr. Gottwald's research re-introduced the ancient technique of using dogs to detect pests and diseases in agriculture. The noses of canines are far more powerful than our most expensive scientific equipment, and they can detect pathogens in real-time without the need to sample and destroy plant tissue. This in-field, real-time, large-scale detection of mealybugs and leafroll virus could be a game changer in California's fight to keep nurseries and vineyards healthy and free from devastating disease.

While Dr. McRoberts serves as the epidemiologist, Ms. Lisa Finke and her staff at Canine Detection Services (Fresno, CA) are performing the majority of the actual research.

They are currently conducting proof-of-concept trials to determine if dogs can be trained to detect vine mealybugs and leafroll virus in grapevines. Ms. Finke has extensive experience using canines for bed bug and Asian citrus psyllid detection.

I (Stephanie Bolton) am leading the project and serving as the principal investigator. The final team member, Dr. Maher Al Rwahnih (Director of Foundation Plant Services), is providing expert technical assistance and thoroughly virus-tested samples for training.

Figure 9: Ms. Finke rewards a detection canine with some play after a correct identification.

The Lodi Winegrape Commission has been actively studying the California grapevine virus situation since 2002, and this current project builds upon that work. If successful, canine detection could apply to more pests and diseases in grapes and other crops, and provide a valuable, sustainable pest prevention tool for farmers in California and beyond. Stuart Spencer, Executive Director of the Lodi Winegrape Commission adds, "We are thankful to the Department of Pesticide Regulation for funding this innovative project that has the potential to benefit the entire California wine and grape industry. The Lodi winegrowing community is proud to be at the forefront of cutting-edge, industry-led research, innovation, and extension."

To sign up for our grapevine virus email list to stay informed of educational opportunities and research progress, send an email to stephanie@lodiwine.com.

The content for this article was originally published to the Lodi Growers weekly viticulture blog on lodigrowers.com and was updated for Lodi Grape Day. Thanks to reviewers Chris Storm and Stuart Spencer for their valuable input.


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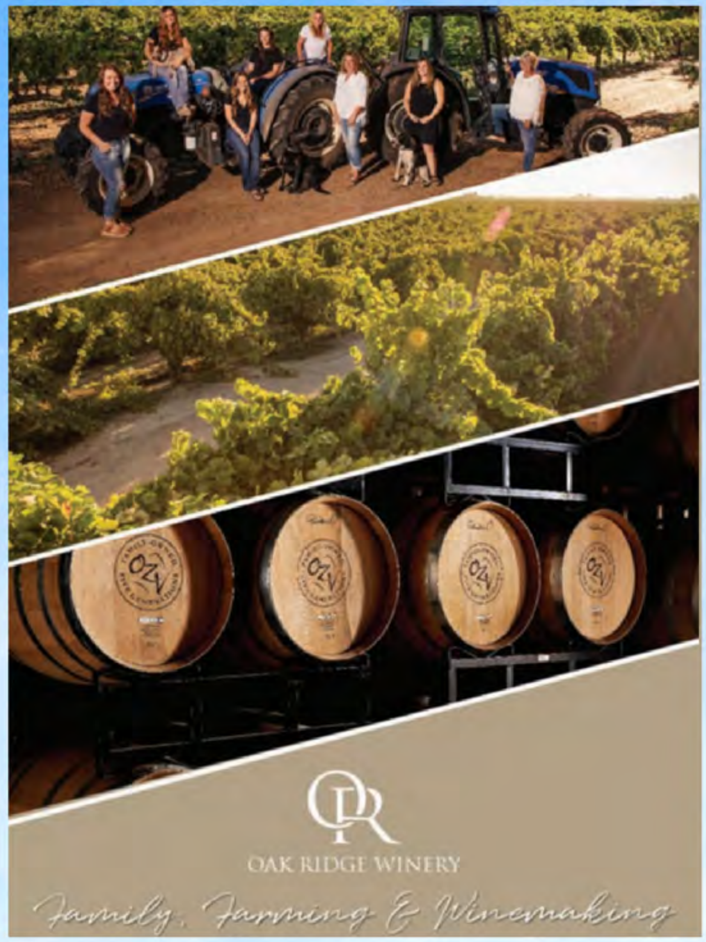
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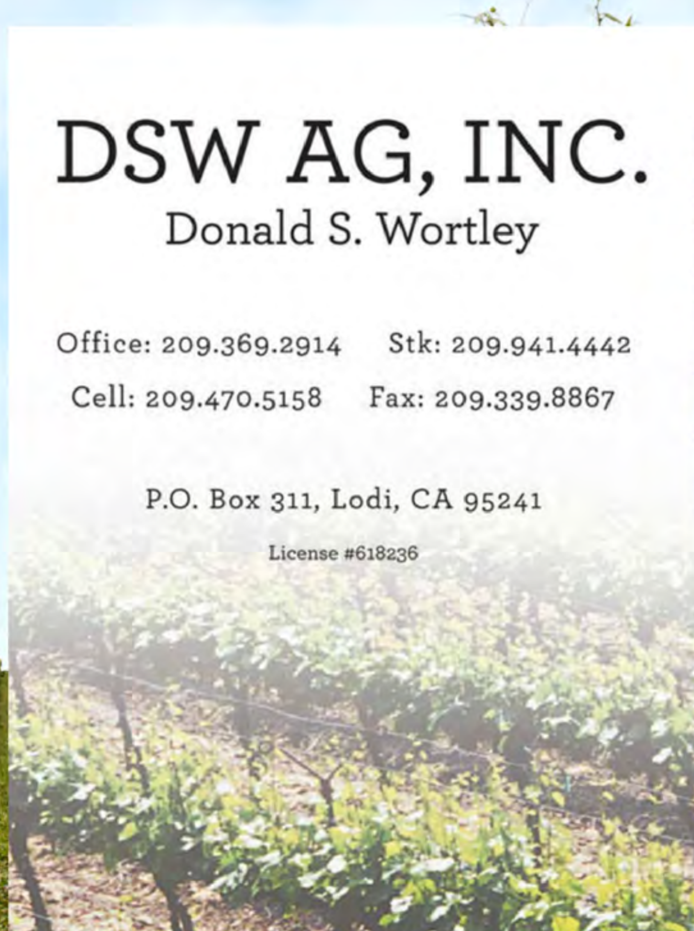
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