Managing Diseases in a Rainy Year

Gabriel Torres, UCCE Tulare & Kings Counties

The climate in California is described as Mediterranean. This means that our summers are dry and hot, while winters are mild and wet. However, the weather in 2019 did not behave as expected. With cool temperatures in February, a drier than normal April, and an unusually cool and rainy May 2019 will be remembered as an extraordinary weather year. It is impossible to say if this would be the new normal, but it is clear, that something happened in our local weather during 2019.

Table 1. Differences in Monthly Average High Temperatures in SJV against the annual average.

NAME	CIMIS ID	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
STRATFORD	15	5.2	-5.3	-0.5	4.4	-6.5	1.3	-0.4	0.7	-1.4
FRESNO STATE	80	5.9	-5.0	-0.9	3.3	-7.7	0.0	0.1	0.1	-2.1
LINCOVE	86	4.6	-3.3	0.6	6.4	-4.6	5.7	3.8	5.0	2.2
WESTLANDS	105	5.9	-3.4	-0.1	7.5	-3.4	6.1	5.0	5.6	1.6
ARVIN EDISON	125	7.9	-3.0	-1.6	4.4	-6.2	2.6	-0.9	-0.1	-1.0
MERCED	148	6.3	-4.8	-0.5	1.8	-6.7	1.0	0.8	0.7	-1.2
PORTERVILLE	169	-2.9	-11.6	-5.4	2.0	-7.1	2.7	0.5	1.6	-1.0
DELANO	182	5.4	NA	-5.0	0.3	-9.9	-2.4	-4.9	-1.8	-3.8

NA- Data not available

By October 1st, 2019, information collected from different CIMIS stations in the San Joaquin Valley (SJV) demonstrated that the average high monthly temperature was lower by 6 F° for February and May (Table 1 and Figure 1). This phenomenon pushed the average high temperatures in February below 60 F° delaying bud break up to two weeks. In May, the average high temperatures were below 80 F°, favoring disease outbreaks.

For precipitation, the data collected from CIMIS indicates annual rainfall was highly variable between locations. Some stations received 30% above annual precipitation, whereas others a received 20% less than average. However, regardless of the annual precipitation accumulation, all the evaluated stations in the SJV saw less than normal precipitation in April (10-90%), and far more than normal precipitation in May (300% to 1400% above normal; table 2 and figure 2).

In the dry San Joaquin Valley, an above average rainy season, especially when it brings a large snowpack, is appreciated. However, rain and dew after budbreak provide the proper conditions for a disease outbreak. When green tissue, water drops, and the proper temperature range, diseases such as botrytis, and Phomopsis can become problematic. Humid conditions can also exacerbate powdery mildew infections by promoting spore release from its overwinter structures.

Botrytis is a disease that can develop in temperatures ranging from 32 to 86 F°. However, the optimal growth is observed when temperatures range between 56 and 77 F°. Botrytis is normally observed at the beginning and at the end of the growing season. During spring and early summer, the disease is can affect all succulent tissue were free water is located (leaves, canes, inflorescences and shots), and it is commonly known as botrytis shoot blight. Between veraison and harvest, botrytis can be observed affecting ripened berries; when matured clusters are affected the disease is known as botrytis bunch rot.

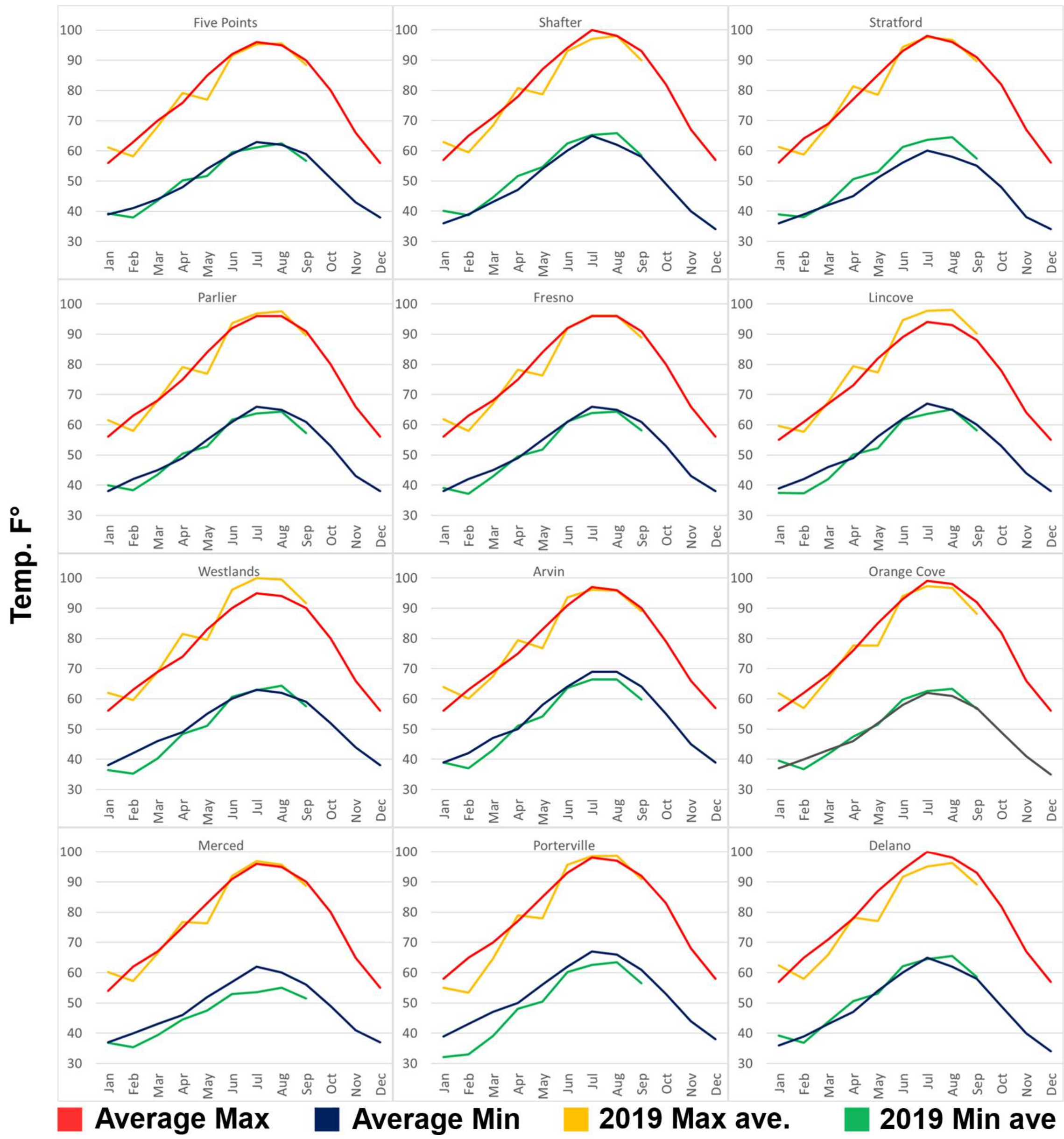

Figure 1. Comparison between 2019 January to September monthly maximum and minimum temperatures and the annual average.

For initial infection Phomopsis needs temperatures between 40 and 95 F°, with an optimal initial infection between 60 and 70 F°. Powdery mildew grows in temperatures between 50 to 95F°, with an optimal growth temperature between 73 and 86 F°. All these pathogens also require high humidity conditions for their initial germination and infection. In SJV vineyards botrytis and Phomopsis are not major problems during dry spring seasons. However, the wet and mild 2019 conditions were favorable for pathogen development. This led to the development of diseases across multiple tissue types, which can be seen in Figure 3.

These diseases can be managed through cultural practices and the judicious use of pesticides. Cultural practices start with canopy management to manage a disease under wet conditions. Improved aeration, through canopy management techniques that open the canopy, helps to reduce humidity, allows wet tissue to dry faster, and improves fungicide coverage. If the amount of rain is significant, adjust irrigation accordingly. Overirrigation, increases vineyard humidity, which can promote the development of fungal infections. Another cultural practice is to have a proper nutrition plan. Excessive use of nitrogen can result in a plant with succulent tissues that are more easily infected by pathogens.

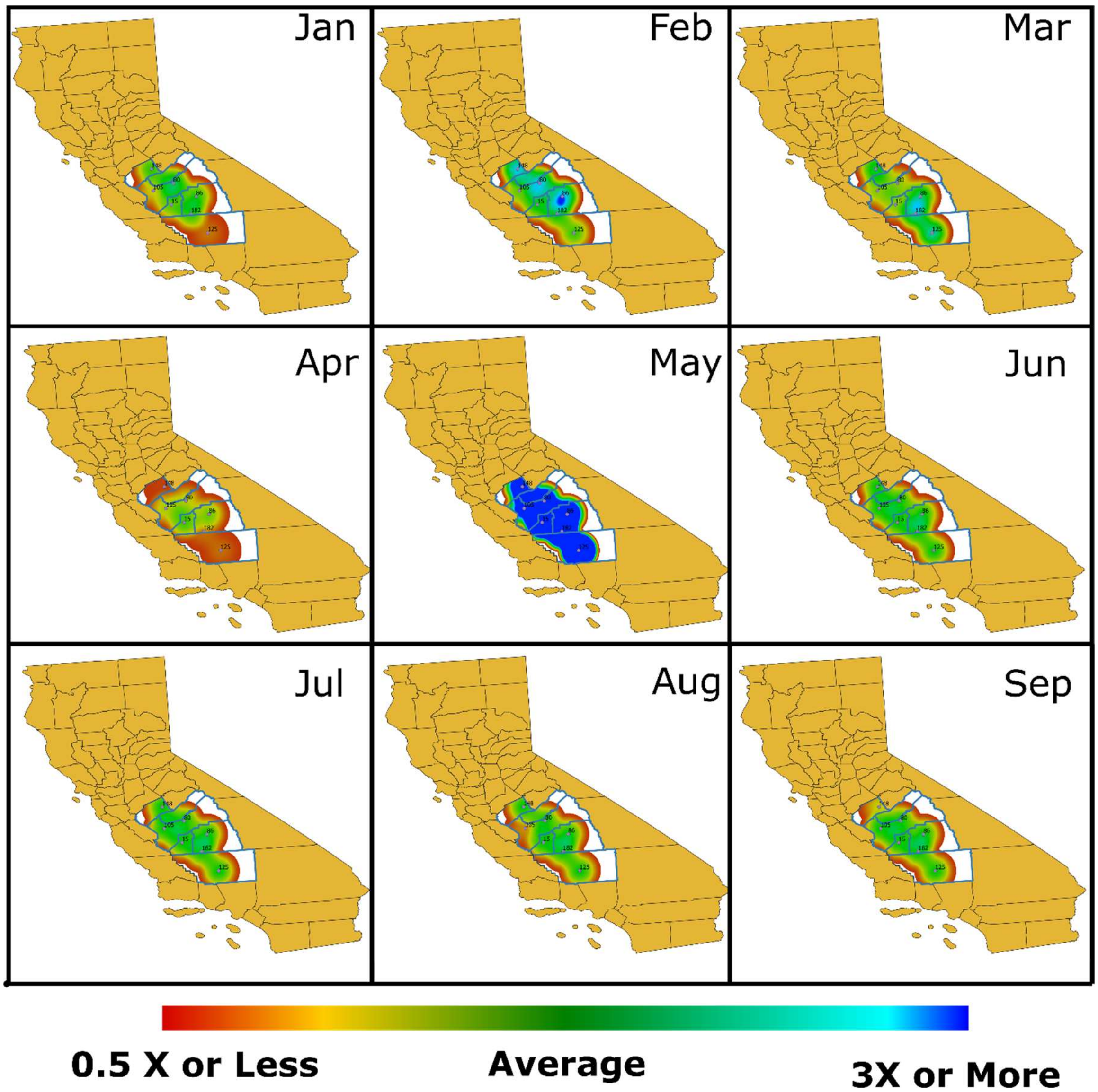

Figure 2. Differences between 2019 precipitation and annual average

Also important is to use fungicides with wide spectrum efficacy. These products usually work as preventive and have contact activity. For these reasons, sprayer calibration is key, and the products need to be applied before infection takes place. Another important step is to determine if a fungicide spray is needed, check weather conditions periodically, and determine if the forecasted conditions are suitable for pathogen to infect your crop. If rain and the optimal temperatures described previously are forecasted, consider spray at least one day before the predicted rain event.

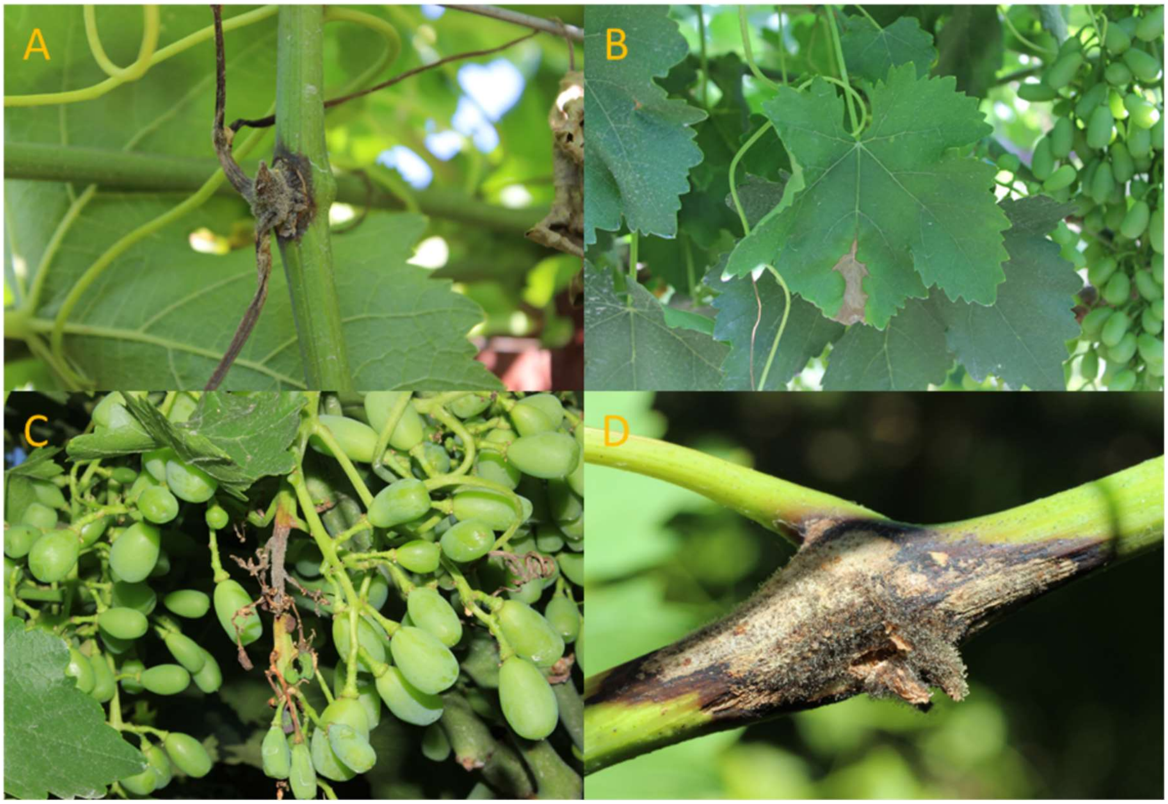

Figure 3. Botrytis shoot blight damage on different plant tissues. A) Nodes, B) Leaves, C) Clusters and Tendrils, C) Canes

During normal conditions soft chemistries and multisite fungicides are sprayed every 10 days. However, if conditions are conductive for disease development, consider reduce the interval to 7 days if the label allows you to do so. When considering stylet oil as a preventive, be sure that temperatures above 90 F° won't occur in the days after its application and that sulfur won't be sprayed during the next 2 weeks after the oil application.

Once infection takes place, the use of synthetic fungicides is advised for non-organic growers. Follow the label instructions and remember to rotate mode of action (FRAC groups) to reduce resistance development. Under severe disease pressure, check your label to see if the interval can be reduced to 10 days. If rain is expected, use a sticker-spreader that is compatible with your selected fungicide.

Prevention is the most successful measure to manage a plant disease. Improve your defensive line by having a good irrigation and nutrition plan. Check weather forecast in a timely manner and plan sprays accordingly. Have products that you expect to use in stock and follow the label instructions. Keep your spray equipment well maintained and keep spare parts so they can be replaced when needed.

Table 2. Monthly precipitation observed in 2019 vs annual avergae precipitation (in).

Location	Station Id	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Stratford	15	1.17	1.52	1	0.45	2.94	0	0	0	0	7.08
Annual Ave.		1.54	1.46	1.61	0.55	0.31	0.08	0	0.04	0.31	5.9
Fresno State	80	2.96	3.63	1.51	0.49	2.41	0	0	0	0	11
Annual Ave.		2.28	2.01	2.48	1.02	0.55	0.24	0.04	0.04	0.31	8.97
Lincove REC	86	1.73	3.5	2.54	0.62	1.92	0	0	0	0	10.31
Annual Ave.		1.93	1.85	2.01	0.94	0.35	0.16	0	0	0.16	7.4
Westlands	105	0.82	1.43	0.89	0.34	1.42	0	0	0.01	0	4.91
Annual Ave.		1.97	1.93	1.46	0.67	0.47	0.08	0.04	0.04	0.24	6.9
Arvin-Edison	125	0.2	1.01	1.85	0.08	2.86	0	0	0	0	6
Annual Ave.		1.14	1.22	1.22	0.51	0.2	0.08	0	0.04	0.08	4.49
Merced	182	2.27	4.14	2.38	0.03	2.26	0	0	0	0.07	11.15
Annual Ave.		2.6	2.36	2.09	0.94	0.55	0.08	0	0.04	0.16	8.82
Delano	148	1.12	0	2.11	0.11	1.85	0	0	0	0	5.19
Annual Ave.		1.3	1.3	1.42	0.67	0.2	0.12	0	0.04	0.08	5.13
Porterville	169	**1.75**	**2.51**	**0.83**	**0.11**	**1.9**	**0**	**0**	**0**	**0.01**	**7.11**
Annual Ave.		2.43	2.19	2.19	1.14	0.4	0.14	0.01	0	0.2	8.7

Vineyard Post-harvest Management Tips

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The end of October generally aligns with the end of the harvest season. While this might start the off-season for grape growers, grapevines still require management beyond pruning after harvest. Successful management strategies postharvest can help to maximize the following year's yield and fruit quality while reduce disease pressure.

Post-harvest Irrigation Management

Depending on production type (raisin, wine, or table grapes), irrigation type (flood or drip), management practices (deficit irrigation), and harvest type (hand vs mechanical) grapevine canopies can end the season stressed and damaged (Figure 1). Therefore, post-harvest irrigation is critical to relieve the vines from stress. This will help maximize the post-harvest canopy photosynthetic activity to accumulate carbohydrate (stored as reserve), to prepare cold hardiness (Greven et al. 2016) and hydrate the vine tissues including root to eliminate embolism (Brodersen et al. 2010). The goal of post-harvest irrigation is to avoid delayed, erratic bud break and ensure canopy early growth with sustainable yield and fruit quality on the following season. How much water is a key question for farmers when applying post-harvest irrigation. For late season varieties the goal is to apply adequate water to maintain photosynthetically functional canopy, while avoiding too much water such that vines push new growth. According to Dr. Larry Williams, University of California at Davis, at least 10% of seasonal irrigation amount should be applied after harvest. So that is approximately equals to 2-3 acre inches of water (assuming the total water budget for a typical Fresno vineyard requires 2 acre foot per year). For early season varieties, with longer postharvest growth periods, the same goal of maintaining photosynthetic activity, while avoiding excessive growth still holds. However due to the extended length of time, and the possibility of more extreme heat the irrigation needs will be much larger. In either case, growers should continue to irrigate until leaf senescence and dormancy starts, or fall rains begin.

Figure 1. Wine grape canopy after mechanical harvest

Drip irrigation can satisfy the need of post-harvest irrigation, although dry winter or the need of salt leaching might require furrow or flood irrigation (Figure 2) to recharge the soil profile and move the salts out of root zone.

Adequate soil moisture post-harvest and during dry winter, will hydrate vine tissues (cordon, trunk and root) preparing cold hardiness and help the budbreak on the following season. Different types of damages can be resulted from lack of soil moisture during the winter and early spring including:

Figure 2. Post-harvest flood irrigation

- Winter freeze damage;
- Erratic spring bud break;
- Delayed early shoot growth;
- Poor fruit set;
- Small cluster size;
- Low yield;
- Poor fruit quality.

Post-harvest Nutrient Management

Post-harvest is a good time to calculate your vines losses from this year's production. Annual loss from harvest are approximately 3 lbs. of N and 5 lbs. of K from each ton of green grapes removed. Assuming no N or K in a vineyard's irrigation water, these nutrients will need to be applied back to the vineyard in the form of fertilizer. It is recommended that yearly bloom petiole or leaf tissue analysis be conducted to monitor vine nutrient status to avoid deficiencies and provide feedback on the effectiveness of current nutritional program. An active canopy is necessary for the vines to assimilate N and K. Therefore, it is best to wait until spring to apply these nutrients. An effective timing of N application is one month after bud break and after fruit set. If the variety is early season, a postharvest application may work if the canopy has an extended period of time that it will remain active. Timing of K application is less restricted and can be applied before or after fruit set.

Figure 3. Soil sulfur band application post-harvest

Post-harvest is a good timing to apply soil amendments (Figure 3), e.g., sulfur and gypsum, to adjust soil pH and improve infiltration.

Dormant Pruning Strategy

Pruning is one of the most important tasks post-harvest. Although it might still be more than a month away from pruning season, growers should take into the considerations now how and when to prune the vines.

Figure 4. More than double number of spurs yielded from mechanical pruning than hand pruning

With the scarcity of labor and increased labor cost, the number of growers using, or interested in adopting mechanical pruning has increased. Many growers have adopted mechanical pre-pruning to save labor cost and improve efficiency of a follow-up hand pruning. In this article I will focus on mechanical box pruning with the possibility of one follow up hand pass to make final adjustments. However, several factors should be considered before switching to mechanical pruning:

- Grape type/variety
- Labor
- Trellis
- Production goal
- Disease pressure

Typical box pruner will yield 4 to 5 inches of spur height above and sideways of the cordon wire. Therefore cane-pruned varieties, e.g., most raisin varieties, normally are difficult to be mechanically pruned. New mechanical pruners have been developed to conduct mechanical cane pruning; however, they usually require a specific trellis. Table grapes are more challenging to mechanically prune due to the trellis type, canopy management needs, fruit quality requirements, and disease pressure, however some table grape growers are experimenting with mechanical pre-pruning of spur-pruned varieties. Simple trellises, like two-wire California sprawl and single high wire, will be the easiest to mechanically pruned, and likely wine grape is the easiest choice among grape types.

Mechanical pruning normally leaves more than double the number of buds per vine as compared to hand pruning (Figure 4). This can translate to more clusters per vine with smaller cluster size due to less fruit set, along with smaller berries due to vine self-regulation. Loose clusters with small berries can be beneficial for fruit quality of wine grapes, e.g., bigger skin/pulp ratio, and reduced cluster compactness in bunch rot prone varieties, e.g., Petite Sirah and Zinfandel (Figure 5). Mechanical pruning might increase the yield per vine initially. However, once the vines are adapted to mechanical pruning, the yield of mechanical pruned vines is generally close to hand pruned vines.

More spurs left by mechanical pruning mean more pruning wounds for trunk disease pathogens to attack. Mechanical pruning early might pose a greater risk of trunk disease, however, less labor input through mechanical pruning means growers have greater flexibility to choose the timing. Late mechanical pruning can be an effective way to reduce trunk disease during the dormant season.

Figure 5. Compact Petite Sirah cluster and bunch rot

Early season irrigation management can be critical for mechanically pruned vines. Mechanically pruned vines result in more rapid early growth than hand pruned vines. Growers might want to apply water and nutrients earlier to satisfy this early growth demand.

Summary

Post-harvest vineyard management is not the finish to this season, but the start of maximizing the yield and fruit quality for the following year, while reducing the disease risk and abiotic stress on vines.

Reference

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Brodersen, C. R., Andrew J. M., Brendan C., Mark A. M., Kenneth A. S. 2010. The Dynamics of Embolism Repair in Xylem: In Vivo Visualizations Using High-Resolution Computed Tomography. Plant Physiology. November 2010. DOI: https://doi.org/10.1104/pp.110.162396

Sudden Vine Collapse

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Several areas in California are attempting to understand a new viticultural issue being called Sudden Vine Collapse. This problem was previously being called mysterious vine collapse, but as the problematic pathogens have possible been identified, it has been relabeled as Sudden Vine Collapse (SVC). The symptoms were first identified in the Lodi area, but have also been confirmed in San Luis Obispo and Santa Barbara Counties, with possible incidence in Monterey County as well. In SVC mature vines with growing canopies, along with developing clusters, will collapse and die in a short period of time, generally 2-6 weeks. Researchers from UC Davis have possibly identified a combination of viruses in combination with specific rootstocks as being the probable source of the collapse. The viruses identified in this complex include Grapevine Leafroll 3 in association with one or multiple other Grapevine Viruses (Vitiviruses). Rootstocks affected so far include Freedom, 3309C, and 101-14. There still appear to be additional factors that are left unaccounted for. Let us take a look at the symptoms that have been identified and what they may tell us about the progression of SVC.

A good starting point is to look at a much better understood and similar situation from walnuts trees called blackline. Blackline is a symptom in walnut trees caused by the Cherry leafroll virus. A grafted, virus free, walnut tree is planted in a new orchard. Once the tree is mature enough it begins to flower, and the infection cycle can start. Cherry leafroll virus is transmissible through pollen, so if any neighboring trees are infected with the virus, they can infect the new orchard during pollination. The virus doesn't cause any immediate major issues, as the scion variety has little effect from the virus. It is when the virus makes it to the graft union that the real problem begins to arise. Many common rootstocks used in walnut production are hypersensitive to Cherry leafroll virus. This means that as the rootstock tissue in the graft unions becomes infected by the virus, the rootstock tissue kills itself. This prevents the virus from spreading into the rest of the root system. However, as the dead tissue builds up in the graft union, it causes the graft union to fail. Once enough of the graft union has died, the scion variety is cutoff from the root system and will die itself. When the graft union is inspected postmortem, the dead tissue shows up as a black line.

Grapevines don't have any viruses that cause as visually dramatic a reaction as blackline. However, virus induced graft union collapse are known in grapevines. This became especially clear in the replant after the failure of AxR#1 in California. AxR#1 (and St. George) is tolerant of viruses in grafted scions, and in some cases can even suppress viral symptoms. When AxR#1 failed to phylloxera different rootstocks were needed to replant the dying vineyards. Wood from the dying vineyards were used to graft onto these different rootstocks, which is when the next problem occurred. The graft union of the new plants failed. During the lifetimes of these vineyards they had acquired viral infections, and when grafted to some of the different rootstocks these infections caused the graft unions to fail to form. The two rootstocks most affected by this problem were Freedom and 3309C, which are both implicated in this current round of collapse. While Freedom and 3309C have both shown issues with virus induced graft union collapse they are far from unique in this characteristic. Many rootstocks can succumb to graft union collapse to the correct (or incorrect in this case) virus or combination of viruses.

A virus causing graft union collapse in plants, and grapevines specifically, isn't that unusual of a problem (and another reason to use virus tested plant material when starting a new vineyard). In the case of

SVC, testing symptomatic vines has led researchers to suspect that this is another case of viral-induced rootstock collapse. The graft union is the first piece of evidence that points in this direction. While not seen in all cases, many failing and dead vines do show visual symptoms at the graft union. In extreme cases this can be more in line with blackline with large sections of discolored and dead wood within the graft union. In more subtle cases the phloem tissue of the scion variety can be seen trying to grow over the rootstock, creating a bulged graft union.

More direct evidence can be seen when testing for starch (sugar) storage in trunks below the graft union. The trunk below the graft union of collapsing vines have a limited supply of starch, while healthy vines see a large supply of starch. This is piece of evidence really informs a lot about the possible cycle of SVC. A lack of starch below the graft union in collapsing vines could indicate that the sugar being produced in the canopy is not able to make it past the graft union. In a sense the graft union is becoming a permanent girdle, starving the root system of carbohydrates. The virus is causing a disconnect between the phloem tissue of the scion variety and the rootstock. We can see this in the unusual graft union growth of some infected plants, or the discoloration and death of tissue within the graft union of other plants. More clearly it can be seen by the lack of starch in the trunk below the graft union indicating that sugars made in the canopy aren't being transported to the root system.

From here the symptoms and evidence lead quickly towards the collapse of the vine. The root systems of collapsing vines have been found to be infected with pathogens that are normally unable to infect healthy vines. More importantly these root systems show very little to no growth of new feeder roots. Feeder roots are the primary site of nutrient and water uptake, and need to be replenished throughout the growing season. As feeder root growth diminishes, so will the plants ability to uptake nutrients and water. The trunk also sees an increase in trunk disease infections, as well as the speed at which these infections advance. Lastly the canopy with reduced root growth and a compromised trunk is left unsupported. In some cases, the canopy becomes stunted, much like in advanced cases of trunk disease. In most cases the canopy continues to grow normally right up to the point that the root system and trunk can no longer support the water and nutrient needs of the canopy. At this point SVC acts suddenly with a complete collapse of the canopy.

The two final pieces of the puzzle is what evidence has been isolated by researchers to suspect the combination of viruses and rootstocks being put forward. The symptoms were first identified in vines grafted onto Freedom, and all tested that has been described to this point has also been with vines grafted onto Freedom. This makes the case for Freedom being involved in SVC is strong. The remaining rootstocks have been seen to follow the same progression as Freedom and have thus been grouped together. This makes their involvement in SVC more associative, but still likely. The Lodi Wine Commission has been following the development of SVC and has other rootstocks they suspect may be involved. These additional rootstocks will need confirmation moving forward.

The identification of the problematic viruses has progressed through testing of collapsing and healthy vines all within the same vineyard. All the collapsing vines showed a combination of Grapevine Leafroll 3 and a Vitiviruses (most commonly Vitivirus A and/or F). The healthy vines did not show this combination of viruses. This satisfies the first of Koch's postulates for the identification of an agent responsible for a disease. The agent (in this case a combination of viruses) must always be found in association with the disease. To confirm that this combination of viruses is responsible for SVC, the viruses will need to be inoculated into healthy plants to recreate the symptoms. Confirmation that SVC is caused by a combination of Grapevine Leafroll 3 and one of the Vitiviruses, in conjunction with a virus sensitive rootstock, will take some time. However, there is strong evidence that this combination is responsible for SVC seen in San Joaquin, Monterey, San Luis Obispo, and Santa Barbara counties.

The San Joaquin Valley also has all the pieces present for SVC to affect us. Up to the writing of this article there have been no incidence matching SVC reported in the San Joaquin Valley south of Stanislaus County. If you have, or have had vines collapse suddenly in the past few growing seasons, please contact your local viticulture advisor. To fully understand this new issue, we need to see as many possible vineyards that have been affected by it. The name of the issue may have been changed from Mysterious to Sudden, but there are still many mysteries left to solve. The UC system as a whole is looking for more examples of this new issue in hopes of gaining more knowledge on the subject.

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Upcoming Meeting

San Joaquin Valley Grape Symposium
Wednesday January 8, 8:00 – 1:00
C.P.D.E.S. Hall, Easton CA
Topics will include grape disease/pest management, vine nutrient, spray coverage and drift prevention
3.0 PCA hours and 3.5 CCA hours

Sunpreme Mechanical Pruning Field Demo
Wednesday, January 22, 8 AM
University of California, Kearney Research and Extension Center
9240 S Riverbend Ave, Parlier, CA 93648
Mechanical pruning field demo on Sunpreme raisin variety with high-wire and quadrilateral trellis

San Joaquin Valley Tree and Vine Website

University of California Cooperative Extension orchard and vineyard advisors are excited to announce a new website: San Joaquin Valley Trees and Vines. You will be able to find old and new articles written on orchard and vineyard management, integrated pest management, nutrient management, and irrigation. We also list all our meetings for easy perusal. Visit https://sjvtandv.com for more information.