Drones in Agriculture: Benefits and Regulations to Know Before You Fly

By Justin Tanner, PhD., University of California Cooperative Extension Farm Advisor, San Joaquin County

Drones are rapidly becoming a valuable tool on farms of all sizes. These unmanned aerial vehicles can scout fields in a fraction of the time it takes on foot, giving growers a bird's-eye view of their crops. Equipped with cameras and sensors, drones can quickly help you identify underperforming areas of your field. Such underperformance can then be evaluated on the ground to identify pests, nutrient deficiencies, or irrigation problems. What once required days of field walking can now be accomplished in minutes, and specialized cameras can detect subtle changes in plant health even before symptoms are visible. From vineyards to orchards to row crops, drones help growers monitor conditions more efficiently and respond to issues faster.

High-resolution drone imagery allows early detection of field problems. Even a standard RGB camera can identify weed patches, water pooling, or irrigation leaks, details that help pinpoint where action is needed (Figure 1). Drones help farmers take targeted steps before minor issues spread, saving time, labor, and inputs by focusing efforts only where they're needed. Many growers find that early detection improves yield, crop quality, and overall management decisions.

Figure 1. Bindweed growing over a grapevine canopy (left). Shoot stunting caused by grapevine trunk disease (right).

Know the Rules

Before launching a drone, it's essential to understand the rules governing its operation. The Federal Aviation Administration (FAA) considers any drone use that isn't purely recreational to be a commercial operation, and that includes all agricultural uses. If you're flying a drone for any beneficial purpose, such as scouting, irrigation checks, or mapping, it is a commercial activity. Under FAA regulations, all such flights are governed by Part 107, which regulates small Unmanned Aircraft Systems (sUAS). Even if no money changes hands, using a drone "in furtherance of a business" (for example, managing your own farm or assisting a neighbor) requires compliance with Part 107 and a valid Remote Pilot Certificate. And remember—while it might be tempting to 'fly under the radar,' the FAA doesn't have much sense of humor about unlicensed operations. Non-compliance can result in significant fines and penalties, so it's best to stay in compliance and aboveboard on every flight.

To become certified, operators must pass the Unmanned Aircraft General – Small (UAG) exam at an FAA-approved testing center. The test costs $175, covers aeronautical knowledge such as airspace, weather, and safety and is open to applicants at least 16 years old. After passing, pilots complete an online application and background check to receive their certificate. Maintaining certification requires a free online refresher course every 24 months, rather than retaking the full exam.

Each drone used must also be registered with the FAA, regardless of weight. Registration costs $5 per drone for three years and can be completed online through the FAA Drone Zone website(https://faadronezone-access.faa.gov/#/). Once registered, you'll receive a unique number that must be visibly marked on the aircraft.

All registered drones must also comply with the FAA's Remote ID rule, which functions like a digital license plate broadcasting a drone's identity and location while in flight. Most new drones include Remote ID capability, while older models may require an add-on broadcast module. Remote ID is mandatory for nearly all drones flown under Part 107, except when operating exclusively in FAA-Recognized Identification Areas (FRIAs) designated zones for hobby and educational flying. Because agricultural operations occur outside these zones, compliance is required.

Part 107 also limits flight altitude to 400 feet above ground level, requires the operator to maintain visual line-of-sight, and allows night operations only if the drone is equipped with anti-collision lighting visible for at least three statute miles. It also restricts flying over people. These rules are designed to maintain safety in shared airspace and protect both pilots and bystanders. Operating commercially without a Part 107 license or an unregistered drone can result in fines and enforcement actions.

Fortunately, the licensing process is straightforward, and once certified, growers gain access to an invaluable management tool. Drones can provide insights that improve efficiency, reduce costs, and support data-driven decisions that enhance both productivity and sustainability.

If you're interested in incorporating drones into your farm operations, you don't have to navigate the process alone. I'm available as a local resource for San Joaquin County growers, consultants, and pest control advisors who have questions about drone technology, the Part 107 certification process, or FAA compliance. Whether you're selecting your first drone, preparing for the exam, or planning safe flight operations, feel free to reach out. My email is jdtanner@ucanr.edu. With the right knowledge and guidance, drones can become a cornerstone of your precision agriculture toolkit—helping you farm smarter, save time, and stay compliant with FAA rules.

UC is leading the Sunpreme and other natural DOV Raisin Research with More Research Needed

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Background

Continued trials at the Kearney Agricultural Research and Extension Center are investigating Sunpreme, a natural Dry-On-the-Vine (DOV) raisin. The current set of trials has two main objectives. The first is to determine how potassium nutrition might affect the quality and yield of natural DOV raisin grape varieties, such as Sunpreme. The second is to conduct basic research to better understand the physiological basis for natural DOV and preharvest shatter, an undesirable trait that appears to be linked to the natural DOV trait.

Sunpreme was the first of a new generation of DOV raisin grapes that offer unprecedented potential for complete mechanization of production (Fidelibus, 2014; Ledbetter and Marini, 2016). Having fruitful basal nodes and a natural DOV trait enables this variety to be pruned and harvested by machine. However, the variety also has an undesirable trait, preharvest fruit drop (shatter), and it may be difficult to fully dry the fruit in years with particularly heavy crops or poor drying weather. It might be possible to develop management practices that can help minimize shattering and optimize drying. Still, there is insufficient knowledge of the underlying physiology of the preharvest fruit drop or the natural DOV trait to identify potentially helpful management strategies. Ledbetter and Marini (2016) showed that spur-pruned vines were equally productive as cane-pruned vines on a t-trellis. This makes spur-pruned vines on a t-trellis (quadrilateral) the standard production method because spur-pruning is less expensive and easier to mechanize than cane-pruning. Quadrilateral trellis systems, which were used for the initial testing of Sunpreme, can be managed with machines. Still, currently available vineyard mechanization equipment works best with single highwire (curtain) trellis systems (Kurtural and Fidelibus, 2021), on which natural DOV varieties have not previously been tested.

Ledbetter and Marini (2016) showed that deficit irrigation improved raisin drying, but reduced raisin quality. It is unknown whether the better drying was due to a direct effect on the berries or, indirectly, due to a smaller and/or thinner canopy, which could improve sun exposure of the drying fruit. Potassium (K) facilitates carbohydrate translocation from leaves to fruit, and K nutrition likely plays an essential role in ensuring timely fruit maturation and yield in natural DOV production. However, no previous K-fertilizer studies have been conducted on natural DOV varieties. Recently (2021 through 2023), we conducted a study to evaluate the effects of rootstock, trellis, and mineral nutrition (40 versus 80 lb. N per acre) on raisin yield and quality. It was determined that modestly increasing the N application rate increased yield, and that the harvested raisins contained approximately 44-52 lbs. N/acre, depending on the N rate. It was concluded that annual applications of forty to fifty pounds of N per acre are probably sufficient to sustain yield and quality (Fidelibus, unpublished data). Beginning in 2024, the focus shifted from nitrogen to potassium, comparing K application rates of 0 lb./acre, 75 lb./acre, and 150 lb./acre. The application rates were based on estimated K removal data from harvested raisins (Fidelibus, unpublished data). Potassium is closely linked to water use and carbohydrate translocation in grapevines, and symptoms of K deficiency have been observed at Sunpreme at the Kearney Agricultural Center, beginning around veraison.

In addition to the mineral nutrition research, in 2025, we began basic research to better understand the physiology of preharvest fruit drop and natural DOV. Preliminary work by Fresnedo-Ramirez et al. (2019)

suggested that the natural DOV trait could be linked to a berry cuticle disorder. However, Ramming (2014) indicated that the cuticle of natural DOV selections was not markedly different from that of Thompson Seedless, a variety that does not naturally DOV. Rais-1, another natural DOV variety, and Sunpreme have substantial preharvest fruit drop. Preharvest fruit drop appears to result from cluster arm abscission (Fidelibus, personal observation). For abscission to occur, an abscission layer must first form, disrupting vascular connections to berries. Two scenarios may explain the relationship between preharvest fruit drop and natural DOV. Our hypotheses were that 1) abscission layer formation may trigger drying, or 2) berry drying induces abscission, possibly as a result of stress hormones (especially ethylene) formed by the drying fruit. These hypotheses were tested by observational studies and by the application of 1-MCP, a plant growth regulator that blocks ethylene action. Data collected for these studies are still being analyzed.

Results

Objective 1.

In 2024, vines fertilized with either rate of K fertilization had higher petiole and leaf K content than unfertilized vines at bloom and veraison (Tables 1 - 4). According to Christensen (2000), >1.5% K in petioles is adequate at bloom, so the fertilized vines had sufficient K at that time, but K was in the marginal range for unfertilized vines. At veraison, the difference in K content between fertilized and unfertilized vines was greater than at bloom, but all the vines had >0.5% K, which was considered the critical value for K at veraison. Potassium content of leaf blades (Tables 3 and 4) was lower than that of petioles (Tables 1 and 2). According to Robinson (2005), leaf blade K values at bloom <1% are considered low, and leaf blade K values between 0.5% and 0.7% at veraison are low, and values <0.5% are deficient. Overall, it appears that unfertilized vines had low to deficient K levels, whereas fertilized vines had normal to low K content.

Potassium fertilization reduced Ca and Mg content in leaf blades at veraison (Table 4). Potassium is known to have a depressing effect on Ca and Mg uptake (Mills and Jones, 1996), so these results are not unexpected. Still, they are a helpful reminder that application of some mineral nutrients can have unintended effects on the uptake of other minerals. These data underscore the need to carefully monitor tissue nutrient levels and fertilize accordingly to prevent nutrient deficiencies. Other than K, most minerals were in a normal range except for B and Zn, which were low or even deficient. Low levels of B or Zn can reduce yields and quality of grapes, although the characteristic symptoms of B and Zn deficiency were not noticed. Even so, B and Zn fertilization were increased in 2025 to increase tissue B and Zn content and avoid deficiency symptoms.

Vines on the high-wire trellis had slightly heavier berries than vines on a cross-arm (Table 5). Rootstock had no effect on berry fresh weight or soluble solids in July 2024, and neither did K fertilization rate (Table 5). However, K fertilization increased raisin yield by 8%, from approximately 3.75 to 4 tons/acre, but there was no benefit in applying more than 75 lb. K/acre (Table 6). Raisin yield and quality were similar on both trellising systems (Table 6). Raisin K content increased as the K application rate increased (Figure 1), but raisin quality was not affected (Table 6). Vines on cross-arms accumulated more Mg in raisins than vines on single high-wire trellises (Table 7), but otherwise, trellis type did not affect raisin mineral nutrient content. Potassium fertilization increased raisin K content, as already noted (Figure 1 and Table 7), and K fertilization also decreased Ca content but increased Mg content.

In 2025, differences between K treatments were even more pronounced than they were in 2024. Vines that remained unfertilized (with K) had much lower petiole K content than fertilized vines at bloom (Table 5), and especially at veraison (Table 6). Vines in different K application rate treatments also had different petiole K content at bloom and veraison (Tables 8 and 9). Because the K was applied in split applications over the course of the season, fertilized vines received the same amount of K by bloom, but vines in the 150 lb K treatment had higher petiole K at bloom, suggesting a carry-over effect from the previous season. Vines receiving 150 lb. K also continued to accumulate K after bloom, as evidenced by their higher petiole K content at veraison than at bloom (Tables 8 and 9).

Yield was higher in 2025 than in 2024, but K fertilization increased yield to a similar extent (approximately 10%) as it did in 2024. Vines that were not fertilized with K produced approximately 4.9 tons/acre of raisins, whereas vines fertilized with 75 or 150 lb. K/acre yielded approximately 5.3 and 5.5 tons of raisins/acre, respectively. However, raisin moisture data have not yet been determined for raisins harvested in 2025, so yield data for that year should be considered preliminary, and quality data are also not yet available for 2025.

Objective 2.

Preliminary work has begun on the second objective. From mid-June through July, we collected weekly samples of Sunpreme grape clusters to track physical and physiological changes associated with natural DOV development and preharvest fruit shatter. At each sampling date, berry weight, diameter, and brix were determined from berries located on the first lateral arm of each of ten representative clusters. Appearance of the berries, pedicels, and lateral arm itself has also been recorded, making notes on the location and extent of any necrotic tissues. Whole cluster weight and soluble solids were also determined, and lateral arm detachment force, an indication of abscission layer development, was also measured. Tissue samples, including the rachis-lateral arm joint and pedicels from different locations along the first lateral arm, were collected and preserved in formalin-acetic acid-alcohol (FAA) for later histological analysis. The objective is to document structural changes over time and correlate them with phenotypic indicators of abscission and berry dehydration.

To assess the potential regulatory role of ethylene in the DOV and shatter processes, we also treated grape clusters with 1-methylcyclopropene (1-MCP), a synthetic plant growth regulator that should block ethylene perception in cluster tissues. The results of this study should provide insight into whether these processes are regulated by ethylene. It is anticipated that these data will help us describe the progression of the natural DOV and shatter processes, and lead to physiological hypotheses we can test in the 2026 field season. Furthermore, this work may also help suggest management practices that could influence natural DOV and/or shatter through cultural or chemical means.

Summary

A potassium (K) application rate study with Sunpreme raisin grapes grafted to 1103P rootstock on bilateral (single-wire) or quadrilateral (22" cross-arm) was initiated in 2024 and repeated in 2025. In 2024, potassium fertilization increased raisin yield by approximately 10%, from 3.76 to 4.13 tons/acre, with 75 pounds K/acre being sufficient to maximize yield. Potassium fertilization did not affect raisin quality, although it increased the potassium content of the raisins. Vines on either trellis had similar yields, with approximately 4 tons of raisins/acre "in the box", regardless of trellis. B and better grades were 62-67%, and field moisture was 13-14%. Preharvest drop amounted to approximately 15% of the potential yield and was not affected by any treatments. Yield was higher in 2025 than in 2024. Vines that were not fertilized with potassium produced approximately 4.9 tons/acre of raisins, whereas vines fertilized with 75 or 150 pounds of potassium/acre yielded approximately 5.3 and 5.5 tons of raisins/acre, respectively. However, raisin moisture data have not yet been determined for raisins harvested in 2025, so yield data for that year should be considered preliminary, and quality data are also not yet available for 2025. Descriptive data and a plant growth regulator study were conducted in 2025 to better understand the natural DOV and preharvest shatter phenomena, but results are not yet available.

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Table 1. Petiole nutrient content at bloom, as a function of trellis type and potassium application rate, Sunpreme, Parlier, CA, 2024.

Factor	B	Ca	K	Mg	Mn	NO_3-N	TN	P	Zn
Trellis									
High wire	29	1.22 b	1.58	0.45 b	49	1170 a	1.11 a	0.35 a	26 a
Cross arm	29	1.28 a	1.46	0.51 a	56	622 b	0.84 b	0.31 b	23 b
Potassium									
None	29	1.26	1.20 b	0.50	49	803	0.95	0.32	24
75 lbs./acre	30	1.22	1.69 a	0.47	50	962	0.99	0.33	26
150 lbs./acre	29	1.27	1.67 a	0.47	58	922	0.97	0.34	25

Table 2. Petiole nutrient content at veraison, as a function of trellis type and potassium application rate, Sunpreme, Parlier, CA, 2024.

Factor	B	Ca	K	Mg	Mn	NO_3-N	TN	P	Zn
Trellis									
High wire	35 a	2.00	2.40 a	0.97 b	195	1650	0.76 a	0.14 a	32 b
Cross arm	32 b	2.00	1.61 b	1.10 a	217	1338	0.66 b	0.12 b	37 a
Potassium									
None	33	1.97	1.22 b	1.17 a	199	1453	0.59	0.14	33
75 lbs./acre	34	2.06	2.38 a	0.96 b	206	1592	0.74	0.13	34
150 lbs./acre	34	1.98	2.53 a	0.96 b	213	1451	0.72	0.14	36

Table 3. Leaf blade nutrient content at bloom, as a function of trellis type and potassium application rate, Sunpreme, Parlier, CA, 2024.

Factor	B	Ca	K	Mg	Mn	TN	P	Zn
Trellis								
High wire	50.4 a	1.55	1.04	0.31 b	107	3.46	0.29	24
Cross arm	45.6 b	1.63	1.06	0.33 a	108	3.32	0.26	22
Potassium								
None	50 a	1.60	0.96 b	0.33	107	3.37	0.28	23
75 lbs./acre	48 ab	1.54	1.08 a	0.31	103	3.39	0.27	23
150 lbs./acre	45 b	1.61	1.09 a	0.32	113	3.42	0.28	23

Table 4. Leaf blade nutrient content at veraison, as a function of trellis type and potassium application rate, Sunpreme, Parlier, CA, 2024.

Factor	B	Ca	K	Mg	Mn	TN	P	Zn
Trellis								
High wire	47.6 a	2.85	0.60 a	0.45	126	2.5	0.15	14
Cross arm	41.1 b	2.88	0.45 b	0.45	120	2.6	0.15	14
Potassium								
None	44	2.98 a	0.44 b	0.49 a	116	2.5	0.15	13 b
75 lbs./acre	47	2.87 ab	0.59 a	0.45 b	127	2.6	0.15	15 a
150 lbs./acre	41	2.76 b	0.56 a	0.43 b	127	2.6	0.15	14 ab

Table 5. Effect of trellis and potassium annual application rate on berry fresh weight and soluble solids, Sunpreme, Parlier, CA, 31 July 2024.

Factor	Average berry weight (g/berry)	Soluble solids (%)
Trellis		
High wire	1.63 a	194
Cross arm	1.51 b	19.3
Potassium		
None	1.53	20.0
75 lbs./acre	1.55	19.3
150 lbs./acre	1.63	18.9

Table 6. Preharvest drop, yield, moisture, and quality grades of Sunpreme raisin grapes as a function of trellis type and potassium application rate, Parlier, CA, 2024.

	Preharvest drop	Yield	Moisture	Quality	
Factor	(%)	(tons/acre)	(%)	(% B & better)	(% substandard)
Trellis					
High wire	13	4.03	13.2	67.3	8.1
Cross arm	18	3.88	14.1	62.2	11.2
Potassium					
None	17	3.76 b	13.7	64.9	9.9
75 lbs./acre	16	4.13 a	135	61.2	10.9
150 lbs./acre	14	3.98 ab	13.8	68.1	8.1

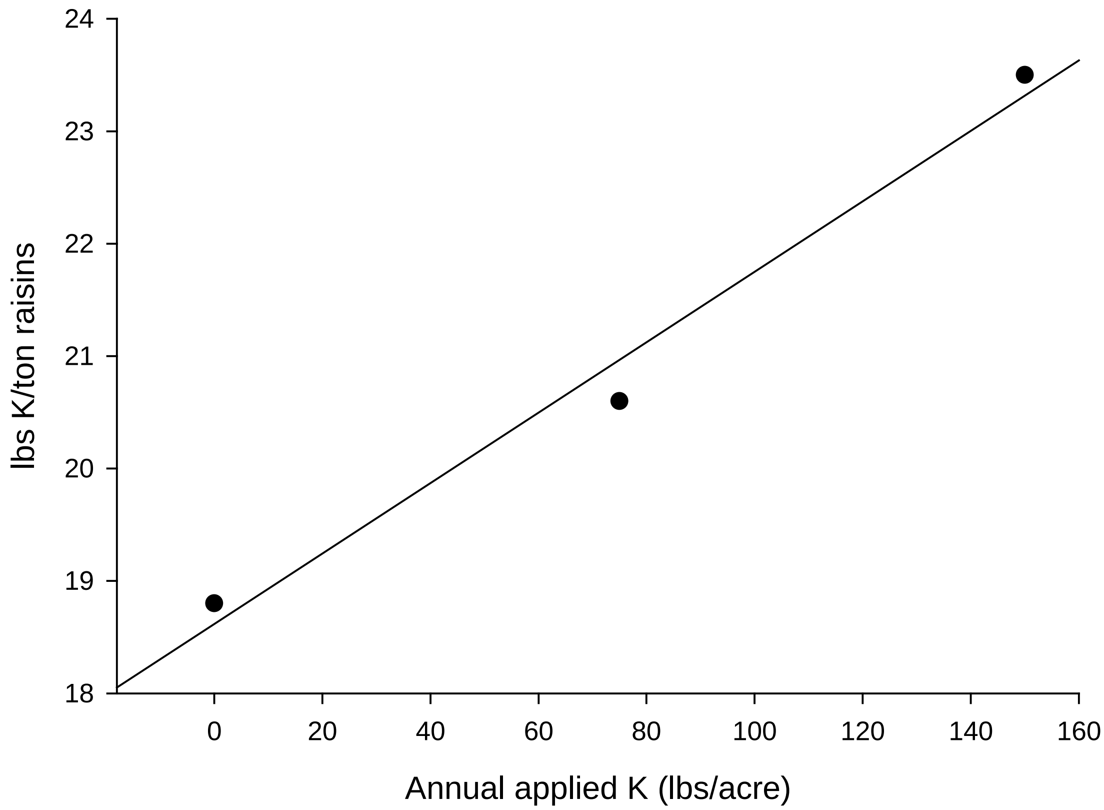

Figure 1. Pounds of potassium (K) per ton of raisins increased linearly with the annual K application rate.

Table 7. Pounds of mineral nutrients per ton of raisins, as a function of trellis type and potassium application rate, Sunpreme, Parlier, CA, 2024.

Factor	N lbs./ton	K lbs./ton	Mg lbs./ton	Ca lbs./ton	B lbs./ton	Zn lbs./ton
Trellis						
High wire	16.5	21.4	0.89 b	2.2	0.02	0.001
Cross arm	15.3	20.5	0.95 a	1.7	0.02	0.001
Potassium						
0	15.5	18.8 b	0.84 b	2.3 a	0.02	0.001
75 lbs./acre	16.3	20.6 b	0.89 ab	2.0 ab	0.02	0.001
150 lbs./acre	15.8	23.5 a	0.99 a	1.6 b	0.02	0.001

Table 8. Petiole nutrient content at bloom, as a function of trellis type and potassium application rate, Sunpreme, Parlier, CA, 2025

Factor	B	Ca	K	Mg	Mn	NO_3-N	TN	P	Zn
Trellis									
High wire	42 b	0.99	1.88	0.46	28 b	2788 a	1.42 a	0.22	104 a
Cross arm	43 a	1.02	1.82	0.49	35 a	2030 b	1.18 b	0.22	94 b
Potassium									
None	42	0.99	1.34 c	0.53 a	30 b	2243	1.29	0.22	93
75 lbs./acre	43	0.98	2.00 b	0.45 b	30 b	2536	1.31	0.19	101
150 lbs./acre	43	1.05	2.21 a	0.44 b	36 a	2447	1.31	0.25	103

Table 9. Petiole nutrient content at veraison, as a function of trellis type and potassium application rate, Sunpreme, Parlier, CA, 2025.

Factor	B	Ca	K	Mg	Mn	NO_3-N	TN	P	Zn
Trellis									
High wire	37	1.87	2.0	0.98	60	1130	0.55	0.07	39 b
Cross arm	35	1.88	1.90	0.97	72	918	0.53	0.07	45 a
Potassium									
None	34 b	1.76	0.88 c	1.18 a	67	913	0.53	0.07	37 b
75 lbs./acre	38 a	1.93	2.13 b	0.99 b	65	1015	0.54	0.06	44 a
150 lbs./acre	37 a	1.94	2.85 a	0.81 c	66	1144	0.57	0.07	45 a

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources

Save the Date
Registration Open Soon!

Southern San Joaquin Valley Grape Symposium

8:00 am to 1:00pm

Friday, February 6, 2026
Tulare, CA

Lunch provided
DPR and CCA CEUs will be applied for

UNIVERSITY OF CALIFORNIA
Agriculture and Natural Resources
UC Cooperative Extension, Fresno County

2026 San Joaquin Valley Grape Symposium

Wednesday, January 7

UC Kearney REC, 9240 S Riverbend Ave, Parlier, CA 93648

SCAN ME

7:00 AM	**Registration and Refreshments**
7:50 AM	**Morning Welcome** *George Zhuang, Viticulture Advisor, UCCE Fresno County*
8:00 AM	**Select Rootstocks for Vineyard Replanting in the SJV** *George Zhuang and Karl Lund, Viticulture Advisors, UCCE Fresno and Madera County*
8:30 AM	**Natural DOV Raisin and Virus-Resistant Grape Breeding** *Dr. Summaira Riaz, Plant Geneticist, USDA ARS*
9:00 AM	**Sunpreme Natural DOV Raisin Rootstock, Trellis, and Nutrient Study Update** *Dr. Matthew Fidelibus, Viticulture CE Specialist, UC Davis*
9:30 AM	**Raisin Moth Management** *Dr. Kent Daane, Entomology CE Specialist, UC Berkeley*
9:40 AM	**Break and Refreshments**
9:55 AM	Coordinator: *Karl Lund, Viticulture Advisor, Madera, Merced, and Mariposa Counties*
10:00 AM	**Recent Issues and Concerns – Laws and Regulations** *Shawn Athayasay, Fresno Ag Commissioner*
10:30 AM	**Impact of Climate Variation and Extreme Weather Events on Grape Production** *Dr. Tapan Pathak, CE Specialist, UC Merced*
11:00 AM	**Update on Spotted Lantern Fly** *Dr. Neil McRoberts, Department of Plant Pathology, UC Davis*
11:30 AM	**Sudden Vine Collapse Update** *Dr. Akif Eskalen, Plant Pathology CE Specialist, UC Davis*
12:00 PM	**Lunch (Sponsored by Sun-Maid, Raisin Bargaining Association, and Sym-Agro)** **Mechanical Pruning on Sunpreme Raisin in Kearney**

Continuing Education: 2.0 PCA and 3.5 CCA hours have been requested.

Any questions? Email George Zhuang at: **gzhuang@ucanr.edu** or call the cell number **(559) 231-1143**

Our programs are open to all potential participants. Please contact the UCCE Fresno County office (two weeks prior to the scheduled activity) if you have any barriers to participation requiring accommodation.

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