

# Grapevine Nursery Stock

Pathogenic status and 2018 planting season review

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PHOTO 1: Sectioned root, trunk and spur of 420A rooting

## Pathogenic Status of Nursery Stock

**THE 2017/18 TESTING, GRAFTING** and production season saw the first detection of Grapevine leafroll-associated virus 3 (GLRaV-3) and Grapevine Pinot Gris Virus (GPGV) in Protocol 2010 certified stock. GPGV is vectored by the fairly ubiquitous Erineum mite, which results in the development of characteristic galls on the upper leaf blade. GLRaV-3 is mealybug-vectored and continues to have perhaps the greatest impact on new vineyards planted with contaminated stock. Many nurseries are now using Protocol 2010 CDFA-certified materials in a greater proportion of delivered stock, but the most popular rootstocks and scion clones may still only be available as Classic CDFA-certified—or even as non-certified materials—propagated from commercial vineyards planted to certified stock.

Rootstock and scion selections that are in high demand and therefore more likely to sell out early—and often only be available as non-certified materials—include Sauvignon Blanc FPS 01, Chardonnay FPS 04, VR O39-16 and 1103P. It is important to read the grapevine purchase sales contract or, if uncertain, seek clarification from the nursery regarding the source of plant material components.

### VINE MEALY BUG (*PLANOCOCCUS FICUS*)

Vine mealy bug (VMB) was again found this year in shipments of green potted vines arriving in Sonoma County. VMB is difficult to detect on grapevine planting stock, and its preferred hiding place seems to be under the wax at graft unions. In an effort to reduce potential shipment of this insect pest, some nurseries have removed wax from the vines before delivery to allow for better contact spraying. The larger nurseries have significant inspection and chemical treatment programs to prevent shipment of contaminated stock, which may include the following:

- Scouting of increase block vines by PCAs
- Inspection of cuttings at time of harvest
- Hot water dipping of field-grown rootstock and scion cuttings prior to propagation
- On-going scouting for insect pests in nursery greenhouses and in nursery row plantings of bare-root vines
- On-going chemical treatment of vines in the greenhouse with products such as: Movento, Applaud, Baythroid XL, Imidacloprid 2F, Montana 4F, Altus/Sovanto
- Pre-shipment wax removal followed by immersion in contact insecticides, such as Assail 70WP and Safari/Venom



LUCIA G. VARELA AND RHONDA J. SMITH

Evidence of VMB under wax at the graft union on a green-growing vine.  
Photo taken August 2017.

It is important that growers notify their local county agricultural commissioners to have vine shipments inspected for VMB before planting. This is mostly a voluntarily requested service by the nursery client. On July 16, 2018, however, **Sonoma County Department of Agriculture/Weights and Measures** issued a 48-hour “pre-notification and hold for inspection of all green growing grapevine nursery stock entering the county” to the agricultural commissioners of counties with grapevine nurseries.

## FUNGAL AND BACTERIAL PATHOGENS

Viruses continue to be the biggest problem to affect nursery stock—especially when non-Protocol 2010-certified materials are used for propagation. However, fungal pathogens associated with the young vine decline/Esca disease complex are still frequently found in finished grapevine nursery product. It is easier to detect the activity of fungal pathogens associated with grapevine stock in dormant product than green potted vines. There is usually some oxidation of tissues in grafted vines at the upper and lower cut tissues of the trunk and at the graft union. This is easy to see in dormant bench grafts and rootings, particularly because the rootstock shaft tissue below ground level (in the nursery row) is translucent white (**PHOTO 1**). Recently grafted green potted vines—which if planted at the most advantageous time—about 16 to 20 weeks after grafting—less frequently show trunk symptoms of fungal pathogen activity. It is, however, fairly easy to see the presence of black gummy tyloses in transverse section in potted vines that have been overwintered (**PHOTO 2**).

Fungal pathogens most commonly associated with grapevine nursery stock include *Phaeoacremonium*, *Phaeomoniella* and *Cylindrocarpum* species. These pathogens are fairly ubiquitous, and it is unusual to find planting stock that is free from them. Such pathogens are known to interfere with wound healing during the propagation process, and this fact renders physical examination of one-year-old dormant stock a useful tool for selecting plants that have lower pathogen loads.



**PHOTO 2:** Section through trunk of 1-year old potted dormant PN 777/RG vine

Practically speaking, provided suitable virus diagnostics have been performed, the most efficient way to select low fungal pathogen load dormant finished product is detailed physical examination. This should include stress test of the graft union conducted by gripping the top of the vine and lower rootstock shaft, while exerting pressure in two planes at 90 degrees to each other, and examination of rootstock disbudding sites and basal wound for complete callus coverage. Flexing the vine also tests for rootstock shaft and graft union-originated lesions (**PHOTO 3**), which can severely reduce vascular capacity. The old adage, “if it breaks, don’t plant it,” holds true. When examined in section, the rootstock shaft of one-year-old dormant bare root vines should be translucent white with pith: wood of no more than 1:2 ratio and none or only minimal vascular discoloration. Upon close examination, vascular discoloration in dormant vines shows the presence of black and brown gummy tyloses that exude from the xylem tissues of the plant (**PHOTO 2**). These exudates result from the vines’ response to the activity of fungal pathogens within the vascular system—but may also be present in dormant vines close to the graft union and basal cut of the rootstock shaft—as a result of oxidation. A certain amount of discoloration close to the graft union and rootstock base of dormant bare root vines is to be expected.

It is more difficult to assess the physical quality of green vines that are ready for shipping. Given that vines have reasonable top growth, one of the most important criteria is that the root ball does not lose its shape when removed from the container—if the root ball does not stay intact, the likelihood of transplant shock is significantly increased. Gently test the graft union while understanding that it will not be completely healed for several more weeks. Shoots should ideally have been cut back at the nursery to stimulate further root and shoot development. Spurs should show some basal lignification with a minimum caliper of approximately 1/8 inch. Vines should be stable in the potting medium—not too much movement of the vine within the potting compost—overly loose vines might indicate insufficient root development.

General nursery sanitation practices are key to the delivery of quality green and dormant vines. The fungal pathogens that cause young vine decline and



PHOTO 3: Basal lesion and limited root system on 1616C.1 rooting



Esca are ubiquitous in vineyards and are frequently found in nursery increase blocks. How the nursery harvests cuttings from the increase block can have a significant impact on the fungal status of cuttings used for propagation. The nursery increase blocks should be far from commercial vineyards, and the production facility should have asphalted road surfaces, cold storage and workspaces that are non-absorptive and regularly cleansed during the daily propagation cycle.

The Pierce's Disease pathogen *Xylella fastidiosa* and crown gall pathogen *Agrobacterium vitis*—pathogenic strain (AVPS)—are bacteria that are most likely to be found in certified stock. If the nursery has a history of delivering crown gall-contaminated vines, then it is prudent to screen all increase block vines for AVPS before undertaking any virus testing. Even in AVPS-negative stock, it is not unusual to find a low percentage of galls present in the finished product. This observation is further evidence that nursery sanitation practices are key to the production of clean stock. It is not difficult to see how stock becomes contaminated when so many different rootstock and scion materials from so many different sources are propagated at the same time in the same production spaces.

## Fungal Pathogens – Recent Observations

Fungal contamination of propagation material may derive from systemic infections of mother vines from which dormant cuttings are obtained, or they may be introduced during nursery propagation processes from infected soils or airborne spores. Nursery fields, as well as hydration tanks, grafting machines and callusing media, are potential sources of infection during propagation (Gramaje et al., 2012). In 2007, Agri-Analysis conducted a survey of 165 non-symptomatic rooted grapevine cuttings selected randomly from various nurseries in California: using PCR assays, 26 percent tested positive for *Cylindrocarpon* spp (CYL), 19 percent for *Phaeoacremonium aleophilum* (PAL), and 4 percent for *Phaeomoniella chlamydospora* (PCH) (Dubrovsky et al., 2007).

FIGURE 1

Abundance Rate of Young Vine Decline Fungi and Eutypa Found During 2017/2018 Season in Comparison With 2007

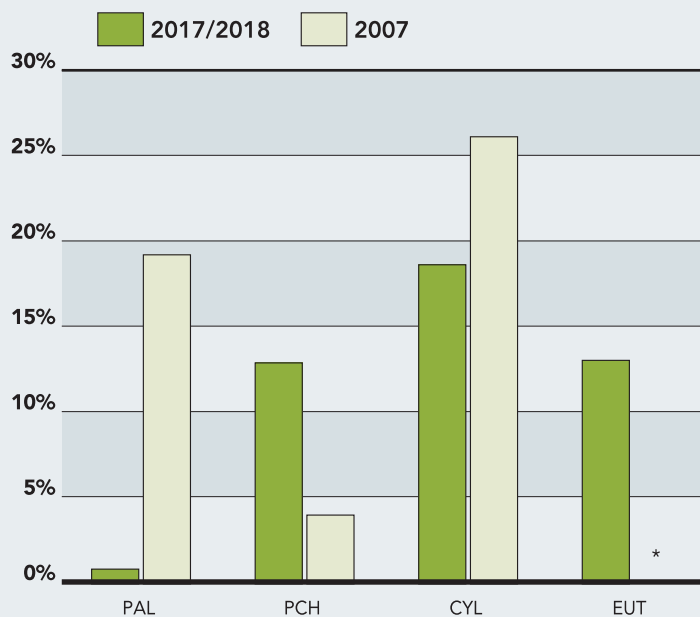


FIGURE 1 compares the incidence rate of PAL, PCH, CYL and Eutypa in 2017/2018 season with that of 2007. It is abundantly clear that these fungal pathogens are present in much higher levels than their virus counterparts in new planting materials and their importance can not overstated.

\* EUT: No data collected in 2007.



**PHOTO 4.** One-year-old green bench grafts of CH Wente/101-14, PN 459/101-14, CH 17/101-14 destined for planting in 2018 growing season were found to be infected by *Cylindrocarpus* spp and *Phaeoacremonium aleophilum*.



**PHOTO 5.** Certain combinations of fungal and viral infections can be deadly. These 25-year-old CH04/Freedom vines are gradually declining. Infected vines tested positive only for GLRaV-3 and *Phaeomoniella chlamydosporum*, one of the fungal pathogens responsible for the Esca/young vine decline complex.

Currently, California nursery certification program and industry propagation practices focus on testing economically important viruses in foundation blocks and nursery increase blocks in order to eliminate their spread. There is no certification requirement to test propagation materials for fungal pathogens. We do not even know what proportion of plant material is already infected with fungal pathogens prior to field planting. Funded by research grants from the American Vineyard Foundation, Dario Cantu's

research group at UC Davis is working on next generation sequencing (NGS) for the early detection and screening of fungal pathogens related to Eutypa canker, bot canker and young vine decline. "The implementation of a certification and quality control program would certainly help decrease the risk of infections incurred at the nursery level, thereby reducing the economic losses caused by these devastating diseases to growers," said Dr. Cantu, associate professor of viticulture and enology at UC Davis.

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## How to Distinguish Callus From Crown Gall

At first blush, it may seem difficult to distinguish large callus growths from crown gall on green and dormant vines. Some of the differences include:

Crown gall	Callus
Tend to be spherical in structure	Do not tend to be spherical
Smooth, uniform surface, amorphous	Knobby, pitted, convoluted surface, resembles redwood burl
Tissue is soft and wet—easy to squeeze moisture from, easy to squeeze out of shape	Tissue is hard and dry. Not easily deformable. May have woody interior
Red varieties tend to have red streaked interior	No red streaking observed
Frequently found at soil line	Rarely found at soil line



Crown gall at soil surface of CS685.1/VR O39-16.1 green vine (20 weeks old)



Surface of callus at disbudding site on rootstock shaft of CS412.1/O39-16.1 green vine (20 weeks old)



Internal structure of crown gall shown above



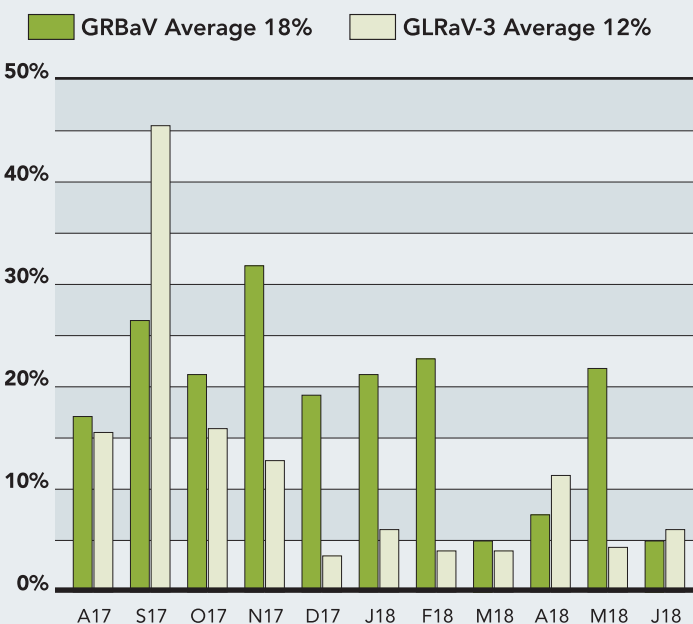
Internal tissue structure of callus shown above

## VIRAL PATHOGENS

Grapevine Red Blotch-associated Virus (GRBaV) and GLRaV-3 are the two most economically important viruses that have been and continue to be routinely found in CDEA-certified nursery stock (**FIGURE 2**). Other viruses, including leafroll variants and vitiviruses A, B and D, are also found, but GRBaV and GLRaV-3 are the two that provide the greatest economic impact—in terms of yield and fruit quality—and are known to be vectored readily by the Three Cornered Alfalfa Treehopper and Vine Mealybug, respectively. Given the production systems used by all grapevine nurseries, the only way to be certain that starting rootstock and scion materials are virus test-negative is to test every increase block plant (mother vine) required for propagation for viruses of concern. If the vines are destined to be planted in the nursery row for sale as dormant bare-root rootings or grafted vines in the following year, then it is prudent also to test for GRBaV and GLRaV-3, either in late fall when symptoms may be present or to test dormant finished product at grading.

**FIGURE 2**

### Abundance Rate of GRBaV and GLRaV-3 Found During 2017/2018 Season



Percent of GRBaV and GLRaV-3 positive samples of all samples tested for these two viruses. Samples consisted of cuttings from existing vineyards, nursery increase blocks, as well as grafted vines. On average, 18 percent were positive for GRBaV and 12 percent for GLRaV-3.

To limit the chance of purchasing virus-contaminated plants, potted vines may represent the best option because they are not grown outside of the greenhouse complex and are usually shipped within 20 weeks of grafting. Consequently, there is a reduced opportunity for re-infection after the original mother vine testing.

To date, grapevine fanleaf virus has not been found in CDEA-certified stock, and apart from Rupestris Stem Pitting virus (transmitted in pollen), the only economically impactful viruses detected in Protocol 2010 certified nursery stock by Stamp Associates are GLRaV-3 and GPGV. GLRaV-3 was detected in a Riparia Gloire (RG 1) increase block located fairly close to commercial vineyards in southern California in winter 2017/2018 while GPGV was found in a 1616C (1616C.1) increase block in northern California during the same period.

## Recent Developments in Our Understanding of Grapevine Viruses

### GRBAV VARIANTS

There are two genetic variants of GRBAV with approximately 8 percent sequence heterogeneity, but with no recognized biological differences among isolates to date. Growers often tell anecdotal stories of vines infected by GRBAV with distinct performance characteristics. However, when such vines were analyzed for GRBAV isolate-typing, no particular correlation was found between isolate type and vine performance, suggesting isolate type does not cause the seemingly different performance characteristics of GRBAV-infected vines. Many grapevine viruses are latent (not showing symptoms nor causing disease) under certain circumstances. We know GRBAV infection is latent in rootstocks and in wild *Vitis* species. **Marc Fuchs** at **Cornell University** surveyed wild *Vitis* species for GRBAV in California counties with and without commercial vineyards. Only wild grapes in regions of commercial vineyards tested positive for GRBAV. Identical GRBAV variants were found in wild and cultivated vines, suggesting virus transfer between them, especially near riparian habitats. Infection was latent in all GRBAV positive wild *Vitis* samples. Wild vine samples from New York have not to date tested positive for GRBAV (Cieniewicz et al., 2018).

### GPGV STATUS SUMMARY

Grapevine leaf mottling and deformation (GLMD) is a grapevine pathology identified in Northern Italy in 2003. Symptoms include chlorotic mottling, mosaic deformation of leaves, shortened internodes, stunting and reduced yield. Yield is most affected in Pinot Gris with up to 80 percent loss reported. Grapevine Pinot Gris virus (GPGV) was later identified to be associated with GLMD disease. Symptom manifestation has been associated with virus variants and/or titer level in infected plants. Clade type A is an asymptomatic GPGV variant and clade types B/C are symptomatic variants. Although GPGV was initially discovered in Pinot Gris, this virus has now been detected in other economically important grapevine varieties, including Napa Cabernet and Chardonnay (Angelini et al., 2016). GPGV transmission is by the Erineum mite *Colomerus vitis* (Malagnini, 2016). During the 2017-2018 season, approximately 1,600 samples were tested for GPGV at Agri-Analysis, 6 percent of which tested positive by RT-PCR. This makes GPGV the third most frequently found virus after GRBAV (20 percent) and GLRaV-3 (12 percent) in all samples tested for these viruses during this season. Recently, researchers in Hungary and Italy (Demian et al., 2018 and Gualandri et al., 2017) surveyed for GPGV in herbaceous hosts (endemic plants and weeds) surrounding vineyards. They found asymptomatic GPGV isolates in six plantations examined besides grapevine: *Silene latifolia* (bladder campion), *Chenopodium* (Goosefoot), *Asclepias syriaca* (Milkweed), *Rosa* (Rose), *Rubus* (Brambles, Raspberries, Blackberries) and *Fraxinus* (Ash). Interestingly, symptomatic variants B/C were not found in their survey, suggesting the wide presence of the latent asymptomatic variant in surrounding weeds, which may serve as reservoirs for the GPGV virus. It is important to note that vine decline and yield loss have not been demonstrated to be caused by GPGV in California.



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## NEW VIRUSES

The 2017-2018 season coincided with the discovery of two new geminiviruses in grapevines. The genome of these viruses is DNA rather than RNA, which is found in most grapevine viruses. Next generation sequencing discovered these geminiviruses. The practical impact of these viruses remains to be elucidated. Perry et al. (2018) reported the discovery of a “Wild Vitis virus 1.” The complete genome of this virus ranged from 3204 to 3278 nucleotides in length, depending on isolate type. The genome most closely resembled that of GRBaV in both sequence (57 to 59 percent identity) and organization. So far, Wild Vitis virus 1 is only reported in non-cultivated (wild) grapevine (*Vitis* sp.) from Napa County, California. Al Rwahnih (2017) reported the discovery of a “Grapevine geminivirus A.” The complete viral genome ranged from 2,903 to 2,907 nucleotides in length. This virus was initially discovered when screening table grape cultivars Black Beet and Nagano Purple in South Korea—1.74 percent of 1,262 vines were found to be positive by PCR, which were derived from 15 grapevine cultivars from six countries across three continents.

## GLRAV-3 UPDATE

On a worldwide basis, grapevine leafroll-associated virus 3 (GLRAV-3) is the most prevalent and economically important virus affecting grapevines. 2017-2018 season witnessed the most single-year increase in genetic variants being discovered thanks in part to next generation sequencing (NGS). **UC Davis Foundation Services** (FPS) alone deposited 27 near full-length GLRAV-3 genome sequences into GenBank between and March and June 2018. GLRAV-3 isolates are highly diverse and even a single vineyard may contain highly diverse isolates of GLRAV-3. At least nine variant groups (I-VII and Santa Barbara 138 and 43-45) are currently known and many more are yet to be identified. Their high genetic variability has made testing and detection even more challenging. Of particular interest was the near full-length sequence of nine GLRAV-3 isolates from California deposited in GenBank by FPS. It confirms the existence of previously known but unpublished GLRAV-3 variants. In 2013, Agri-Analysis developed a new testing method in an effort to encompass broadest isolates/variants of GLRAV-3 for detection. At that time, some samples showed typical “leafroll-like” symptoms but consistently tested negative for GLRAV-3 by published RT-PCR methods and by commercial reagents, but were positive by the Agri-Analysis method. Agri-Analysis PCR-amplified the heat shock protein 70 (HSP-70) region of the genome from one sample, and obtained a 488-bp gene product and sequenced it. Interestingly, when this sequence was blasted against the GenBank database, only 80 percent homology was found with a single isolate from **Washington State** published by Rayapati’s group in 2006 (Soule MJ). After the full genome sequences of nine new GLRAV-3 isolates/variants were made available by FPS, this 488-bp sequence was again blasted in GenBank. A total of ten matches were found, of which nine were new isolates discovered by FPS and one by Washington State in 2006. Of the nine FPS isolates, four (4) matched the Agri-Analysis sequence at 99 percent, three (3) 98 percent, one (1) 88 percent and one (1) 80 percent.

Date	GenBank Accession #	Isolate Name	Variety	Query Coverage	Identity
03-10-18	KY764333.1	GLRAV-3 Trc138	cv. Chardonnay	100%	99%
03-07-18	KY707825.1	GLRAV-3 isolate Rod 96	cv. Roditis	100%	99%
06-22-18	MH521117.1	GLRAV-3 isolate Pin244b	Cv Pinot Noir	100%	99%
06-22-18	MH521091.1	GLRAV-3 isolate Cab248	cv Cabernet Sauvignon	100%	99%
06-22-18	MH521103.1	GLRAV-3i isolate FPS245	Vitis vinifera	100%	98%
06-22-18	MH521098.1	GLRAV-3 Isolate Cha246	cv Chardonnay	100%	98%
02-15-18	KY707824.1	GLRAV-3 isolate Pro 95	vinifera cv. 11184	100%	98%
06-22-18	MH521109.1	GLRAV-3 isolate Kat255b	Cv Katelin	100%	88%
06-22-18	MH521093.1	GLRAV-3 isolate Cha106	cv Chardonnay	100%	80%
06-15-06	DQ780887.1	GLRAV-3 isolate WA C3-1	Vitis spp. Grapevines	100%	80%

Noteworthy is the GLRAV-3 Trc138 isolate. According to Al Rwahnih (2018), this isolate belongs to a new monophyletic group that was outside the previously known seven I-VII groups (Maree, 2015). This data and analysis suggests that since 2013 the Agri-Analysis protocol has been detecting these unique GLRAV-3 isolates, although newly discovered, in vineyard and nursery samples, while other methods may have failed to detect them (Al Rwahnih et al. 2018).

## Propagation Materials Update

The 2018 production season was a bad one for the reliable production of green vines grafted to VR O39-16. Several nurseries that usually have good success grafting this in-demand Xiphinema index/fanleaf virus-tolerant rootstock had difficulty completing orders. The situation was exacerbated by the growing interest in 36-inch-tall grafted “uber” vines that require three times as much rootstock as standard vines—thus reducing the inventory of materials available for re-grafting. The good news is that the better nurseries told customers of potential problems soon after grafting failure was noticed—providing some opportunity to develop alternate plans—or re-graft if sufficient stock was available.

VR O39-16 is inherently difficult to propagate – and unlike other rootstocks, such as 101-14MG, 110R and 1103P—the outcome is by far less assured. So as a matter of course, it is good to be in regular communication with your nursery regarding graft take and progress of orders grafted to VR O39-16. GRN-1, a recently released rootstock offered as a potential alternative to VR O39-16, is also difficult to propagate and in high demand. A limited number of nurseries have routine success grafting GRN-1, so again it is good to discuss likely outcomes before placing an order.

A February 2018 presentation by **Rhonda Smith**, UCCE Viticulture Farm Advisor, Sonoma County, provided some of the first real data from trials of the GRN-1 to GRN-5 rootstock series in comparison with other commonly used stocks, including VR O39-16, RS3, 1616C and 1103P. The trial of 11 rootstocks grafted to Cabernet Sauvignon was planted in a highly infected X. index site in Geyserville, northern California. Smith’s February 2018 presentation is available here (<http://cesonoma.ucanr.edu/files/288458.pdf>).

In summary, the GRN series and especially GRN-1 compared favorably with VR O39-16.

It is not clear why the 2017/2018 season was difficult for grafting VR O39-16 at several nurseries. In fact, it seems that success was greatest at some nurseries that grafted later in the season. Possible theories relating to poor VR O39-16 take include reduced winter chill hours during the early pre-harvest 2017/2018 season, on-going issues with drought and vine physiology and extremely hot weather conditions during the late growing season at some locations. Nursery propagation is not (yet) an exact science.

Not only are difficult to propagate rootstocks, such as VR O39-16 and GRN-1, in great demand but limited supply, so too are increasingly popular stocks, such as 1103P and 110R. These are becoming rootstocks of choice for extremely water-challenged regions in California, such as the Central Coast. They are drought-resistant and, given sufficient water to become properly established, can be dry-farmed. Considering the future of rainfall in California is very much in doubt it, is easy to see why these rootstocks are in demand.

Nurseries are now taking orders for Dr. **Andy Walker's** Pierce's Disease-resistant white- and red-fruited selections. The hold up on release of these materials seems to be the legal department at the University of California. Some nurseries do have these selections under propagation and are taking orders for 2020 and beyond.

## PLANTING WINDOW: BARE ROOT DORMANT STOCK VERSUS GREEN POTTED VINES

The pros and cons of green potted vines versus dormant bare root are many and debatable. Green vines offer the advantage of limited production time exposure to potential viral vectors, but it is challenging to get vines ready for on-time delivery. In reality it takes a good 20 weeks to realize finished product from the time of grafting—and even then, not all the vines may be ready for delivery. Counter intuitively, early grafting of green vines—theoretically providing for earlier plantings—sometimes result in late deliveries as early season weather conditions, acts of God and vine physiology conspire against the nursery. In reality it is difficult to get large numbers of green vines ready for planting much before early/mid June. Fortunately many growers are not ready for planting much earlier than this. Late plantings through early August are not unusual and provided green vines are properly finished—with full root systems and good lignification of shoot spurs—and provided the vines are farmed with a view to managed growth and shut-down prior to frost season—plantings will be successful. Late plantings with VR O39-16 are more difficult due to the extremely fleshy nature and susceptibility of this rootstock to frost. One strategy used successfully by **Derek Cronk** of **Colinas Farming Company** in Rutherford is to mound all VR O39-16 grafted vines before frost. Cartons are removed and earth piled up above the graft union (**PHOTO 8**). Vines are then uncovered in early spring.

Dormant bare-root plants provide greater certainty that vines will be ready on time—for February onward plantings—but this also depends on the nursery obtaining accurate pre-harvest counts of the nursery row take. Be prepared for bare-root shortages of difficult-to-propagate rootstocks, such as 420A, Riparia Gloire and 1616C. VR O39-16 is generally not offered as a dormant bench graft due to difficulty of propagation.

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# How to Secure Clean, Quality Planting Stock

## NURSERY PARAMETERS

- Open to frequent visits with excellent communication
- Order as soon as possible
- Modern, clean sanitized operations facilities
- Increase blocks far removed from commercial vineyards
- How frequently does nursery test IB's for viruses?
- Which materials are Protocol 2010 CDFA certified?
- Clean facilities produce cleaner vines

## PROPAGATION MATERIALS SAMPLING STRATEGIES FOR VIRUS DETECTION

- Pre-grafting: visually evaluate, test and tag every IB vine as late as possible while leaves attached
  - Walk both sides of rows
  - Select contiguous healthy vines, rows, blocks
  - Woody canes close to crown: virus titer
    - ~ GLRaV-3, GRBaV, GLRaV-1, GVB, GVA
  - Green shoot tips: 3C Alfalfa hopper (*Spissistilus festinus*) GRBaV
  - Pre-screen for *Agrobacterium vitis* if necessary
- Post-grafting: use statistically significant methods to sample finishing or finished product
  - Visual evaluation of bare root finishing product in nursery row

## FINISHED PRODUCT EVALUATIONS

- Fungal pathogens affect graft union and propagation wound healing
- Careful examination of product essential:
  - Root systems
  - Trunk discoloration
  - Graft unions



**PHOTO 8:** Late-planted green potted MB596/VR O39-16 vines mounded before first frost. November 2, 2017. Rutherford, CA

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