

# UC Davis' Role in Improving California's Grape Planting Materials

M. ANDREW WALKER\*

The first *Vitis vinifera* grapes were planted in California by Spanish Missionaries as they established Missions from San Diego to Sonoma. This grape became known as Mission and was the primary *V. vinifera* cultivar until the 1840s Gold Rush. The era between 1850 and 1890 saw a rapid viticultural expansion, the introduction of many new varieties, and the destruction of vineyards by phylloxera and Pierce's disease. In 1880, the University of California was directed to "provide for special instruction ... in the arts and science of viticulture..." by the California Legislature in response to the growing demand for wine and grapes and to combat phylloxera. Bioletti was the first at UC to import grape varieties. Olmo traveled the world on viticultural pursuits and sent back hundreds of varieties and clones. His collecting efforts form the core of UC Davis' Foundation Plant Materials Service collection and virtually the entirety of the USDA National Clonal Germplasm Repository collection. Olmo's grape breeding activities are highlighted by the release of 31 wine, table, raisin, and rootstock varieties, including the internationally popular Redglobe Perlette, Ruby Seedless, and Rubired. Olmo's clonal improvement program helped direct the world's clonal improvement efforts, most notably selecting Chardonnay clones that fueled this cultivar's expansion from about 10 000 acres in 1974 to over 100 000 in 1999. Alley expanded on Olmo's clonal selection work, with important work in improving the quality and productivity of Cabernet Sauvignon. In 1952 the grape clean stock program at Foundation Plant Materials Service (FPMS) began at UC Davis and soon after Goheen initiated the process of heat treatment to rid cultivars of damaging viruses. The current multimillion dollar facility evolved from a small shed and includes the Grapevine Importation Program, which is actively importing clones and varieties from around the world.

KEY WORDS: clean stock program, certification, ampelography, cultivars, varieties, viticulture history

Spanish Missionaries brought viticulture to San Diego, California, in 1769 with the development of the first in a series of Missions that finished with the construction of the Sonoma Mission in 1823. Prior to the Mission Period in California, Spanish conquistadors and clergy colonized Mexico in the 1500s, and began the development of European agriculture with the introduction of citrus, grapes, and olives [52]. The long sea voyage in the 1500s made it difficult to bring rooted plants or cuttings, so seeds were brought instead. It is likely that seed from a number of grape varieties were imported, but it seems that only one survived to the present: a grape now known as Mission. The Mission grape also exists in South America where it is known as Criolla, Criolla chica, Pais, or Quebranta, and a larger berried form exists in Argentina, Criolla grande. These grapes are considered to be sibling seedlings of the Spanish grape Monica, although there is little direct evidence to support these claims. I have a photocopied and non-referenced guide to Spanish variety synonyms that lists Cepa de Cerdaña as a possible synonym. This name may refer to a Cerdaña a small Spanish town about 15 km east of Ornes in western Spain, and may provide more information on the origin of Mission. There are also records of a muscat grape in California and Arizona in the late 1700s. It is unclear whether this grape was of seedling origin like Mission, or was imported as a cutting or rooted plant from Spain [33].

Vineyards were established at the Missions and in

their vicinities, and experience gained by grape growers determined which coastal areas were best suited to viticulture. By the 1830s viticulture began to flourish in the Los Angeles basin and Europeans became aware of the region's potential. The Viña Madre in San Gabriel had grown to about 200 acres by 1834. At about this time, Jean-Louis Vigne became the first immigrant to import varieties from Bordeaux; however, records of what varieties he established and whether they survived do not exist [33]. Other Europeans joined Vigne, and they also brought new varieties and viticultural practices to California [33,35,52].

The California Gold Rush in the late 1840s prompted a huge influx of immigrants from the Eastern United States and Europe into California, and the Mission acreage expanded in the southern state to meet their wine needs. Viticulture also began moving north into the Sierra Nevada Foothills and into Sonoma and Santa Clara Counties. American hybrid grapes, such as Catawba and Concord, came with settlers and miners from the eastern United States. European immigrants recognized the potential of California for viticulture, and they began to import a greater diversity of *vinifera* types.

Agostín Haraszthy stands out among these European importers and was widely regarded as the most prolific. It is claimed that he imported over 200 000 cuttings and rooted vines into the State, from which 492 varieties were eventually recorded [33,35]. These grapes were collected from western and eastern Europe and form the basis for California's current industry. Haraszthy also developed grape nurseries in Santa Clara and Sonoma to distribute his imported varieties.

\*Department of Viticulture and Enology, University of California, Davis 95616-8749, USA [awalker@ucdavis.edu].

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He is sometimes credited with establishing Zinfandel in California after collecting this grape in Hungary. However, research by Charles Sullivan [30] makes it clear that others imported Zinfandel into California including Antione Delmas who listed it (as Zinfandel) in his San Jose nursery catalog in the 1850s. It could also be found in William Robert Prince's Long Island, New York Linnaean Botanic Catalog in 1830 as Black Zinfandel. The European origin of Zinfandel remains unclear, but Haraszthy's efforts were extremely important and were later regarded as a "princely gift" by Charles Wetmore [35].

Mission was the dominant grape variety in 1860, but the number of varieties was increasing. The Catawba craze of the 1850s [33], which touted the fine sparkling wine this *V. labrusca* × *V. vinifera* hybrid was hoped to produce, sparked interest in many American hybrids that were widely planted in the State. Settlers from the eastern United States brought rooted grapevines to plant in California, and Californians began importing *V. vinifera* varieties from East Coast nurseries. These grape importation efforts also introduced an unwelcome intruder — grape phylloxera. Appleton [4] recounts his discovery of phylloxera in Sonoma with O. W. Craig on 19 August 1873. However, the first signs of phylloxera damage in California vineyards appeared well before 1873 [4,8,20]. It is very likely that the first settlers from the eastern United States brought phylloxera with them on rooted vines carried across the country and that this pest first started attacking vines in the 1850s.

The discovery of phylloxera had a large impact on the history of California viticulture [4,8,9,18,20]. The State Legislature established a State Viticultural Commission, a Phylloxera Board, and mandated the Department of Viticulture and Enology at the University of California in 1880 [32,37]. These entities led to the importation of phylloxera-resistant rootstocks from Europe, efforts to catalog and describe California grapes and regions, advances in viticultural and enological techniques, and consideration of importation and quarantine procedures [32,34,35,36,37].

California viticulturists [19,31] monitored French progress with phylloxera-resistant rootstocks. As it became apparent that phylloxera could be controlled with resistant American *Vitis* species, Californians began to import these native American species and graft onto them. *Vitis riparia* and *V. rupestris* seed and cuttings were collected and shipped from the Mississippi Valley in massive numbers. The native *V. californica* was also examined for resistance, and 300 000 cuttings were grafted in 1883 [32,33]. This species seemed resistant at first, but was later claimed to be susceptible [7,12,14], perhaps because *V. californica* × *V. vinifera* hybrids, which were rapidly forming [25] around the state, were tested in place of pure *V. californica*. Recent research results found that selections of *V. californica* that appear to be pure and not hybridized with *V. vinifera* have good phylloxera resistance [11].

European rootstocks began entering California in the early 1900s and set the stage for increased importation and extensive rootstock evaluation efforts that continue to this day. These introductions from Europe and the eastern United States also promoted concerns about the concomitant introduction of diseases and pests on this plant material. Such concerns were expressed in the First Annual Report from the State Board of Viticultural Commissioners in 1881 [36]. They warned against uncontrolled importations from Europe and the eastern US, the haphazard distribution of cuttings and vines in the State, and the movement of fruit bins and other items from phylloxera-infested to uninfested vineyards. These concerns continue to be voiced in California and around the world.

By 1881, viticulture was expanding across the state. New vineyards were being planted on resistant rootstock and infested sites were being abandoned. There were 5713 acres and 300 growers in the Los Angeles basin [28]. The dominant variety was Mission, but several German varieties were common (such as Blaue-Elben, a dark form of Kleinberger or Berger), as well as Zinfandel and Charboneau (or Corbeau), a grape that was known as Charbono in California [34]. Muscat of Alexandria was grown for raisin production. Sonoma County had the greatest grape acreage with 7000 acres planted from the San Pablo Bay (the Carneros region) to Cloverdale, and 3000 of these acres were planted after 1877. Mission was also the dominant variety in the North, but newer plantings of Zinfandel, Riesling, Golden Chasselas (Palomino), Traminer (Gewürztraminer), Burger (Monbadon), and Flame Tokay (Ahmeur bou Ahmeur) were common.

Between 1880 and 1890, viticulture rapidly expanded across California. An excellent ampelography was published in 1884 by Charles Wetmore, detailing the many varieties being grown and providing important information on use and origin [34]. This report was also prophetic in many ways including current wine-making practices. In regard to Zinfandel, Wetmore announced; "In many places, such as Yolo and San Joaquin Counties, it should be classed, I think, as a white wine grape", clearly foreseeing the production of White Zinfandel in today's Central Valley. Wetmore also began importing varieties he felt should be tried in warmer areas of California, where wine color was typically lacking, such as Tannat, Alicante Bouschet, and Petite Bouschet. He also imported Pinot Chardonnay which was later included in the Chardonnay clonal selection efforts of Ernest Wente. Wente gathered selections from other Chardonnay sources including a Montpellier, France nursery and he encouraged Harold Olmo, at the University of California Davis, to include them in his clonal selection program (Wente Winery Newsletter). Through these efforts, Chardonnay rose from its status as a minor variety in the 1960s with less than 250 acres to its present position as the number one wine grape in California with over 100 000 acres.

By 1891, St. George rootstock was widely recommended and utilized as vineyard acreage expanded and

was replanted. There were 22 683 acres in Sonoma County, up from about 10 000 acres in 1880, with about 850 growers and 21 varieties in production, although by far the most common were Mission and Zinfandel. Napa County had fewer acres in grapes with 18 229 acres, about 630 variety growers, and 25 varieties and Zinfandel number one. Santa Clara and Alameda Counties were also major grape growing districts with 11 523 and 6826 acres, respectively. The variety mix was far more diverse in these counties, with 46 varieties on record in Santa Clara, and 55 varieties in Alameda. The variety mix in these two counties included French, German, Italian and Spanish grapes [29].

Grapes were also being grown in many areas of Southern California, although Pierce's Disease began devastating acreage by 1886 in Anaheim and the surrounding area [10]. In 1891, there were about 140 growers and 4695 acres in Los Angeles County with Zinfandel, Mission, Trousseau, Burger, and Mataro (Mourvedre), and Muscat of Alexandria for table and raisin grape production as the primary varieties. San Bernardino County had 3615 acres and about 310 growers with about 70% in Muscat of Alexandria for raisin production. Mission and Zinfandel were the primary wine grapes on about 1000 acres. San Diego County was also primarily producing raisin grapes on their 4,627 acres with about 310 growers. The 130 acres of wine grapes grown in San Diego included Zinfandel, Mataro, Grenache, and Carignane [29].

As it is today, most of California's grape acreage was in the San Joaquin Valley in 1891. Fresno County had the greatest acreage with 49 500 acres and over 1600 growers. Muscat of Alexandria was grown on 42 910 acres for raisin production and wine grapes occupied 5574 acres, but no wine grape varieties were listed in the acreage report. Tulare County also had about 9900 acres in Muscat of Alexandria for raisin production. Nine hundred of San Joaquin County's 1246 acres were planted to wine grapes, and the balance was in table grapes. No varieties were listed in the 1891 report, but it is likely that Mission and Zinfandel were dominant [29].

California had a total of 166 952 acres in 1891. Zinfandel was the primary wine grape, although about 60 varieties were grown. Marsanne, Verdlho, and Mataro were relatively common, Cabernet Sauvignon, Cabernet franc, Merlot, and Thompson Seedless were rare, and no Chardonnay acreage was listed [29].

By 1912, there were about 385,000 acres of grapes in California [6]. One hundred eighty thousand of these acres were in wine grapes, with 50% in the San Joaquin Valley, 35% in the Coastal regions, and 15% in Los Angeles basin. There were 130 000 acres of raisin grapes, 90% planted in the San Joaquin Valley, but almost all of this acreage was Muscat of Alexandria. Table grapes were concentrated in the Sacramento and San Joaquin Valleys where about 67 500 of the 75 000 acres were grown. The variety missing from this list is

Thompson Seedless, which did not become popular until the influx of Armenians into the San Joaquin Valley occurred after the Armenian Massacre in 1915.

In 1880, the State of California initiated the Department of Viticulture and Enology, which began at the University of California Berkeley. Eugene Hilgard first worked on improving California wine with better varieties and wine making techniques. Frederic Bioletti was soon hired to head the Department of Viticulture and he began researching improved wine making techniques and determining which varieties were best suited to specific regions of the state [5]. Bioletti also began introducing varieties and documenting the origin of others.

Many of the viticultural efforts were directed at combating phylloxera during the late 1800s and early 1900s. Rootstock importations from Europe began in the late 1890s, and Frederick Flossfeder was appointed by Bioletti to conduct rootstock trials at UC Davis and the Kearney Agricultural Center [7]. Flossfeder obtained a wide range of rootstocks from what was available in California and through importations, and began field trials with Riparia Gloire, St. George, Rupestris Martin, 420A, 157-11C, 3306C, 3309C, 101-14Mgt, AXR#1, AXR#9, 1202C, and Lenoir. His work was later expanded upon by Harry Jacob who realized that trials conducted at two sites could not lead to rootstock recommendations for use at all the State's regions.

Rootstocks were also imported from Europe for testing by the United States Department of Agriculture. George Husmann, a pomologist for the USDA, reported on his field trials with 102 rootstocks in 1915 [14]. He tested these rootstocks for phylloxera resistance and viticultural performance at vineyards in Colfax, Chico, Elk Grove, Fresno, Geyserville, Guasti, Livermore, Lodi, Mountain View, Oakville, Sonoma, and Stockton. By 1930 he had focused his rootstock efforts on AXR#1, AXR#2, 1202C, Lenoir, St. George, Riparia Gloire, 420A Mgt, 161-49C, 101-14 Mgt, 3306C, 3309C, 1616C, 1613C, Dogridge, and Ramsey [13,15].

Harry Jacob began his viticultural career at the University of California Davis in 1925. He recognized the importance of field testing at a wide range of sites and tested a set of rootstocks at 99 sites in 17 counties. The following rootstocks were tested although not all sites contained all rootstocks and the block designs and replication numbers also varied: Riparia Gloire, St. George, 3306C, 3309C, 44R, 57R, 99R, 110R, 420A, 5A, 8B, AXR#1, 1202C, 93-5C, Ponzio XX, 41B, Lenoir, 1616C, 1613C, Dogridge, Salt Creek (Ramsey). Lloyd Linder carried on Jacob's work and published two summary papers [16,17]. These rootstock trials were designed to examine the viticultural performance of rootstocks and did not emphasize their pest resistance, although an effort was made to use sites that had been infested by phylloxera or nematodes.

The next series of grape germplasm trials at UC Davis were the studies of Maynard Amerine and Albert Winkler aimed at determining which varieties were

Table 1. Varieties bred by H. P. Olmo at the University of California, Davis. Acreage values are from 1999 CDFA report and total 58143; varieties below 50 acres and rootstock are not reported.

Variety	Parentage	Use	Bred/Intro	1999 Acres
Early Niabell	Campbell's Early 4x X Niagra	juice/table	1942/1962	
Niabell	Campbell's Early 4x X Niagra 4x	juice/table	1942/196	247
Royalty	Alicante Ganzin X Trouseau	color/concen	1938/1962	835
Rubired	Alicante Ganzin X Tinta Cão	color/concen	1938/1962	13 151
Scarlet	Golden Muscat X Teinturier	juice	1935/1946	
Beauty Seedless	Scolokertek kiralynoje X Black Kishmish	table	1941/1954	562
Blush Seedless	Emperor X Z4-87 (Emperor, Queen of the Vineyards, Ribier, IP 75)	table	1966/1981	
Centennial	Gold X Q25-6 (Gold, Emperor, IP 75)	table/raisin	1966/1981	
Christmas Rose	S44-35c X 9-117D (Emperor, Hunisa, and IP 75)	table	1962/1981	1 314
Delight	Scolokertek kiralynoje 26 X Sultanina marble	table	1938/1948	
Early Muscat	Muscat Hamburg X Scolokertek kiralynoje	table	1943/1958	67
Gold	A3-94 X K3-78 (Muscat Hamburg X Sultanina) X (Muscat Hamburg X Scolokertek kiralynoje)	table	1951/1958	
July Muscat	I26-11 X K4-41 (Muscat of Alexandria X Flame Tokay) X (Muscat Hamburg X Scolokertek kiralynoje)	table	1950/1958	
Perlette	Scolokertek kiralynoje 26 X Sultanina marble	table	1936/1948	5 089
Queen	Muscat Hamburg X Sultanina	table	1931/1954	101
Ruby Seedless	Emperor X Pirovano 75	table	1939/1968	8 288
Redglobe	L12-80 X S45-48 (Emperor, Hunisa, Nocera)	table	1957/1981	16 263
Canner	Hunisa X Sultanina	table/canning	1931/1958	
Dawn Seedless	Gold X Perlette	table/raisin	1966/1981	
Emerald Seedless	Emperor X Pirovano 75	raisin/table	1939/1968	
Calzin	Zinfandel X Refosco	wine	1937/1958	
Carmine	F2-7 X Merlot	wine	1946/1976	
Carnelian	F2-7 X Grenache (F2-7 = Carignane X Cabernet Sauvignon)	wine	1949/1974	1 735
Centurian	F2-7 X Grenache	wine	1949/1976	402
Emerald Riesling	Muscadelle (CA) X Rielsing	wine	1935/1948	624
Flora	Semillon X Gewürztraminer	wine	1938/1958	
Helena	Zinfandel X Refosco	wine	1937/1958	
Ruby Cabernet	Carignane X Cabernet Sauvignon	wine	1936/1948	8 873
Symphony	Grenache gris X Muscat of Alexandria	wine	1940/1983	592
O39-16	Almeria X rotundifolia male #1	rootstock	1948/1989	
O43-43	Hunisa X rotundifolia male#1	rootstock	1948/1989	

best suited to California's viticultural regions. Coincidental with these studies was Winkler's use of heat unit summation as degree days to define grape growing regions in California. These concepts were developed by Bioletti [6] who derived the concept from an 1883 study by Angot in France. In 1944, Amerine and Winkler published one of California's most important viticultural studies — "Composition and quality of musts and wines of California grapes" [3]. This massive work detailed wine and must analyses for 122 varieties with over 15 000 tasting records from small scale wine-making. Many of the varieties that are currently being reconsidered for use today were tested in these trials, while others, like Merlot, were not yet considered important.

Harold Olmo was hired by Winkler in 1931 to begin breeding grapes. He continued his grape breeding and

improvement efforts until his retirement in 1979. He remains one of the most recognized viticulturists in the world. Olmo developed new table, raisin, wine, and juice grapes and worked on several rootstocks. His first crosses were made on 12 May 1931 when he crossed Ribier with Sultana and Muscat of Alexandria with Austrian Seedless and Black Corinth to initiate a table and wine grape breeding program that has continued to the present. He produced thousands of selections and released 31 varieties. He also imported many varieties from around the world to complete the UC Davis collections and to aid his breeding program. Many of these varieties were acquired during research and consulting trips around the world including Iran, Pakistan, India, Portugal, Spain, and Tunisia. Olmo also collected grape species in the United States and northern Mexico and obtained species and Hybrid Direct

Producers (French and American Hybrids) from other national and international breeders. His collections now reside in the USDA National Clonal Germplasm Repository at Davis and form one of the world's best grape germplasm collections.

Olmo was also involved in clonal selection of grape and helped define and initiate this aspect of the world's grape improvement programs. He began his clonal work by selecting variants in vineyards across the State emphasizing good cluster formation, high yields, fruit quality, and disease-free status with varieties such as Cabernet Sauvignon, Pinot noir, Burger, Semillon, and Riesling. He also worked with more obscure (at least at the time) varieties the most notable being Chardonnay, as mentioned above. When Olmo began working with Chardonnay it was considered to be very shy bearing. The clones he developed are the foundation of California's success with Chardonnay and combine high yields with high fruit quality. Clonal studies require the comparison of multiple selections on multiple sites. Olmo collected many of his selections from vineyards in California and also imported selections from Europe. He once stated that he wasn't sure if the French always sent us their best clones; perhaps due to their unwillingness to part with valuable germplasm, or evidence that the environment plays a very large role in clonal expression.

Olmo is also widely regarded for his ampelographic expertise. He would often receive clusters and shoots from growers seeking help with identifying or confirming a variety. However, these were the days before FedEx and overnight delivery, and the samples would arrive with desiccated leaves and rotten and moldy fruit. Given the condition of the samples, he resorted to the only useful organ left, the seeds. Olmo developed a seed collection from hundreds of varieties that allowed him to conclusively identify samples. He also teamed with Winkler during 1937 and 1938 to publish an excellent series of variety descriptions in *Wines and Vines* including: Aleatico [45], Cabernet Sauvignon [41], Colombar (Sauvignon vert at that time) [42], Muscadelle [46], Refosco (Crab's Black Burgundy) [43], Saint Macaire [47], Semillon [48], Sylvaner (Franken Riesling) [44], Tinta Amarella [51], Trousseau [49], Valdepeñas (Tempranillo and Tinta Roriz) [50], and Zinfandel (with Amerine) [26]. These articles remain timely and help direct and explain today's efforts with these grapes. The Cabernet Sauvignon article has a telling statement referring to the origin of many of the State's grapes: "Like many of our varieties in California, the Cabernet Sauvignon, as far as we know, has crept in without a formal announcement." Given today's proclivity towards "slipping a few sticks in the suitcase", I suppose future knowledge on the origin of many varieties will remain obscure. Olmo also completed a checklist of California grapes in 1964 in which he catalogued 114 wine grapes, 53 table varieties, 22 rootstocks, and 2 raisin grapes [21]. He began the publication of a California Ampelography with the release of Chardonnay through the Wine Institute in 1971 [23].

One of Olmo's least appreciated activities was the initiation of the Foundation Plant Materials Service at UC Davis. He published a *Wines and Vines* article in 1951 that discussed the degeneration of varieties via viruses and mutations, the establishment of a certification program with disease-free and clonally selected cultivars, a plan for a foundation vineyard and certified mother vines at nurseries, and suggested a methodology for importing grapes from outside the country [22]. These thoughts paved the way for the creation of the current Foundation Plant Material Service (FPMS), which was first managed by Curtis Alley [1] beginning in 1953, followed by Leon Corey in the early 1970s. In 1975, FPMS was moved out of the Department of Viticulture and Enology and was combined with the UC Davis' Foundation Seed Certification Service, and in 1981 Susan Nelson-Kluk became manager of FPMS. Austin Goheen served as the principal scientific advisor at FPMS from the early 1960s through 1986. He was a plant pathologist with the USDA Agricultural Research Service stationed at UC Davis. His work focused on grape viruses and greatly expanded our knowledge of fanleaf, leaf roll and corky bark diseases. The current FPMS is the one of the world's foremost examples of a plant certification program and is managed by Deborah Golino.

Goheen promoted the concept of virus elimination through the use of thermotherapy and initiated the selection numbering system used at FPMS that designates selections based on the duration of virus therapy they received. This system was based on the supposition that the temperature scion buds were subjected to for the elimination of viruses might also mutate the DNA of the host grapevine. He found that the longer buds were treated with high temperatures the greater the chance that all viruses would be eliminated from the buds. Goheen assigned different selection numbers to the same genotype exposed to different durations of heat treatment so that any genetic changes to the grape selection could be detected. There is little evidence that heat treatment causes genetic change other than the elimination of virus effects, thus FPMS selection numbers within a given variety often represent the same clonal genotype.

Goheen also maintained the grape importation license at UC Davis and imported many new varieties and clones into California. While reviewing old records he discovered that Hilgard had established variety trials at locations across the state, and that maps to these sites still existed at UC Berkeley. Only the trial at Jackson in the Amador County Foothills was in existence and it was overgrown with shrubs and trees when Goheen located it. Hilgard's records stated that 100 varieties were planted there, and Goheen's observations found that a very low percentage of these varieties were infected with leafroll virus (about 18% compared to his estimates of about 80% in commercial vineyards). He reasoned that this low level of infection was the due to the fact they were imported before the widespread use of rootstocks in Europe, a practice that

encouraged the rapid spread of virus through propagation procedures. As a result of these discoveries, FPMS distributes Jackson clones of several varieties.

Grape varieties and clones continue to be introduced into California through legal and illegal channels as interest in new varieties and clones heightens. There are sources of untapped germplasm that would greatly benefit table and winegrape growers and breeding programs and these will continue to enter California for evaluation and perhaps eventual use. The history of grape improvement in California presents a story of a young industry learning to adapt to California's climates and soils. Viticulture in California continues to change and improve, and further improvement will be dependent on access to high quality plant materials.

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