Use of Phylloxera-Resistant Rootstocks in California:

Past, Present and Future

Editor's Note: The following is the first installment of a multipart series written by UC viticultural and enology experts regarding the past, present and future of rootstock selection and use for California growers.

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Introduction

The destruction of California vineyards planted on AXR#1 rootstock by biotype B phylloxera, as well as the continued infestation of own-rooted vineyards, began a revolution in rootstock use in coastal and northern winegrape regions. The soils in these regions are ideal for phylloxera infestation, but the nearly complete reliance upon AXR#1 and St. George over the past 25 years has left viticulturists with little experience on which to base their selection of other rootstocks.

This three-article series reviews the need for rootstocks and their use in coastal and northern California grape growing regions. It will be divided into the following parts: 1) The Past, which examines how rootstocks use evolved; 2) The Present, which will review the information available for rootstocks recommendations and will describe the current patterns of rootstock use in coastal and northern California; and 3) The Future, which will address the challenges presented by new pests and will discuss the need for a new generation of resistant rootstocks.

1. The Past. The history of rootstock use in California can be divided into four phases: 1) the early experience, pre-1900; 2) the screening work of Bioletti and Husmann; 3) the field trials of Jacob and Lider; and 4) the discovery of biotype B phylloxera and the current use of alternative rootstocks.

1. Early work, pre-1900. Phylloxera was first identified in California in 1873 and was found to be associated with a declining vineyard in Sonoma Valley. The discoverers were sure that this was the same insect responsible for the widespread destruction of French vineyards. In retrospect, they believed that the insect was responsible for vineyard damage in Sonoma County as far back as the early 1860's. The initial spread was slow due to the geographical isolation of vineyards and to a scarcity of the aboveground, winged form. In the first annual report of the State Viticultural Commission in 1881 (Wetmore, 1882), four remedies for phylloxera were given: planting in sandy soil, submersion, insecticides and, lastly, resistant rootstocks. As closer attention was paid to European experience, limitations of the first three control measures were realized. In later reports resistant rootstocks were featured much more prominently.

By the 1893-94 Report of the Board of State Viticultural Commissioners, several lessons had been learned. Firstly, most compounds or concoctions alleged to have insecticidal activity against phylloxera were proven useless. These purported "cures" for phylloxera in California ranged, as they had in France, from the unusual to the preposterous. V. Mayet wrote, "Speculations and fancies came to us from all social ranks and from every corner of Europe. The better class of those who made recommendations ...were generally the most ignorant; and they were the most tenacious when their ideas bordered closest to folly." What few treatments were effective, such as carbon bisulfide, were found to require at least annual, if not more frequent, application and were viewed ultimately as temporary measures against phylloxera's onslaught.

Secondly, in their rush to replant vineyards destroyed by phylloxera, early California viticulturists, like their European counterparts, initially used wild grapevines indiscriminately. It was generally believed that any native grapevines could be used as rootstocks and would be resistant to phylloxera. Huge shipments of "wild" cuttings from the Mississippi Valley were reported. They soon learned that not all *Vitis* species were equally resistant to phylloxera and not all species were adapted to commercialization; some did not propagate well or failed for reasons other than phylloxera resistance. They were particularly fond of *Vitis riparia* and *V. rupestris* and considered at least a half-dozen other species.

Thirdly, they found that the significant natural variability within a species, affected the viticultural performance of native vines. It was not enough simply to have "true" *V. riparia* or *V. rupestris.* To achieve satisfactory results, these wild species had to be examined and selected for superior production and vineyard uniformity. By the end of the 19th century, Hayne strongly recommended utilizing clonal rootstock selections. The rootstocks Riparia Gloire and Rupestris St. George, are examples of this selection effort and are still being used today.

2. Work of Bioletti and Husmann. After the turn of the century, efforts in California were conducted on two fronts: one led by the USDA's George Husmann, and the other at the University of California under the leadership of Frederick Bioletti.

From 1904 through about 1920, Husmann tested rootstocks at 12 USDA field stations, including sites near Oakville, Sonoma, Lodi, and Fresno. (The Oakville site is the same vineyard used for research today by the UC Davis Department of Viticulture and Enology. It carries the name "Old Federal Vineyard" in recognition of this heritage.) In their final report, Husmann and co-workers highlighted the rootstocks 1202C, 1613C, St. George, Dog Ridge, and AXR#1 for their "wide adaptability and also resistance to the attack of phylloxera." No distinction was made as to the relative phylloxera resistance of rootstocks in this group.

Bioletti and co-workers (1921) did most of their rootstock experimentation at UC Davis (then called the University Farm) and what is now the UC Kearney Agricultural Center near Fresno, although they utilized grower-cooperators as well. Bioletti preferred the rootstocks 3309C, St. George, 420A, 1616C, Riparia Gloire, AXR#1, and 1202C, among others. He described AXR#1 by saying that "...unlike most crosses containing vinifera, its resistance to Phylloxera is quite sufficient..." Several of the rootstocks suggested by Bioletti for specific conditions never reached significant commercial importance, including Rupestris Martin, 157-11 Couderc (*berlandieri x riparia*), 106-8 Mgt [*riparia x (cordifolia x rupestris)*], and 3306C (*riparia x rupestris*). In a later report, Bioletti and co-workers recommended primarily 3309C and 41B. Although they were quite satisfied with the field performance of 420A, they rejected it because it was difficult to propagate.

The work of both Husmann and Bioletti can be best described as screening trials in that they attempted to sort through a large number of European rootstocks. They also utilized a wide variety of scions which had commercial potential at that time. Both researchers, by the nature of their screening efforts, were able to draw only general conclusions. However, their results were quite useful given the large numbers of rootstocks available at that time.

Despite the lack of a clear recommendation by the researchers, St. George became the preferred rootstock used by North Coast growers from the turn of the century until Prohibition. This occurred with full knowledge of St. George's viticultural limitations, e.g. its poor performance in dry, shallow soils and its propensity for contributing to poor fruitset, especially in very fertile vineyards sites.

3. Jacob-Lider trials. In the post-Prohibition era, the USDA ceased working on winegrapes and phylloxera, and it fell to the University of California to continue the effort. In 1929, UC Davis viticulturist Harry Jacob commenced what was to become the most comprehensive series of rootstock trials in California's history, eventually conducting more than 100 trials. Jacob appeared to have gleaned lessons from his predecessors Husmann and Bioletti. He recognized the importance of site conditions. His trials were not located at university field stations but rather with growers in the production areas. These were not the screening trials of Bioletti and Husmann; these were trials from which firm recommendations could be made.

In 1943, Jacob issued a preliminary report summarizing the results of his ongoing project. He acknowledged that AXR#1 was less resistant to phylloxera than St. George, and even failed in dry sites "where phylloxera attacks are likely to be most severe." Nevertheless, he reported that AXR#1 produced the most vigorous and productive vines in non-nematode sites. However, he also favored 99R, 1202C, and 420A for specific site conditions. Jacob had apparently already concluded that no one rootstock would suffice for all vineyards.

After Jacob's premature death in 1949, he was replaced by Lloyd Lider at UC Davis, who carried on and con-

Table 1. Rootstock use and performance in California; a re-analysis of the data of Lider (1958), indicating the number of times a rootstock was used in 16 trials and comparing the relative rootstock performance (AXR#1 = 100) for all scions and selected scions.

Rootstock	Number of trials in which rootstock appeared		Relative yield (AXR#1 = 100)	
	All scions[z]	Selected scions[y]	All scions	Selected scions
AXR#1	16	7	100	100
St. George	16	7	77	72
1202C	15	7	82	99
3309C	13	6	78	84
1613C	11	6	64	70
Dog Ridge	11	6	84	77
110R	10	3	90	102
5A	10	6	73	97
3306C	7	2	84	93
1616C	5	3	61	58
41B	4	2	72	71
420A	3	2	95	107

[z]All scions (number of trials): Sauvignon vert (3), Palomino (1), Zinfandel (4), Barbera (1), Cabernet Sauvignon (1), Franken Riesling (1), Petite Sirah (1), Sauvignon blanc (1), Chardonnay (1), Mission (1) and Grenache (1).

[y]Selected scions: Zinfandel (4), Cabernet Sauvignon (1), Sauvignon blanc (1) and Chardonnay (1).

cluded the work. Of the original 100 trials, Lider selected 17 for a summary report in which he stated that, on average, AXR#1 out-performed all other rootstocks in terms of growth and yield. He concluded that AXR#1 was a good choice for coastal winegrape production. The phylloxera resistance of AXR#1 was described by Lider as only "moderate" while other *vinifera* x *rupestris* hybrids, such as 93-5C, were rejected as insufficiently resistant. In that report, Lider referred to foreign experience in which the phylloxera resistance of AXR#1 had proved inadequate. Near the end of 19th century AXR#1 had been recommended by French nurseries, but that situation did not last long as it soon fell into disfavor due to insufficient phylloxera resistance. Other incidents of AXR#1 failure were known to have occurred in South Africa and Italy.

During the 25 years which followed Lider's publication, AXR#1 performed consistently well in California vineyards (presumably under significant phylloxera pressure). Preferred by nurserymen and appreciated by viticulturists and winemakers, AXR#1 thus became the predominant rootstock in North Coast vineyards. Any of the original concern about phylloxera resistance expressed in Lider's article was forgotten or ignored. In 1974, Lider and co-workers returned to six of the trials included in the 1958 report and confirmed that AXR#1 continued to perform adequately in comparison to other tested rootstocks. In the 1980s, however, the picture changed dramatically.

4. Biotype B phylloxera and alternative rootstocks. The first documented case of failure of a California vineyard grafted on AXR#1 occurred in Napa Valley in 1983. Investigation of that problem led to the identification of a new strain of phylloxera, called biotype B, in 1985. This aggressive form of the aphid showed an ability to reproduce on AXR#1 roots at a much faster rate than the more common phylloxera called biotype A.

At first, it was not clear that the problem was entirely due to a new biotype; significant questions surfaced about the involvement of misnamed rootstocks and/or drought effects. Common to the early sites of biotype B discovery was the presence of non-AXR#1 rootstocks mixed in the vineyard, including 93-5C, a *vinifera* x *rupestris* hybrid with little phylloxera resistance. What role, if any, these off-type rootstocks played in the development of the biotype B problems is unknown and still a matter of speculation. By the end of the 1988, additional discoveries of declining AXR#1 vineyards had been made indicating that the problem had spread considerably. In December 1989, after a season of further research, the UC Phylloxera Task Force determined that the data were clear; biotype B was the cause of AXR#1 decline and it was recommended that its use be discontinued immediately.

In many respects, the California experience with AXR#1 closely parallels that of South Africa as detailed by Perold (1927) more than 50 years earlier.

"For over twenty years Aramon Nos. 1 (AXR#1) and 2 have been used everywhere as stocks at the Cape with conspicuous success...Now hundreds of acres of these vineyards have been uprooted and replanted with 101-14 and 1202. The vines on Aramon were evidently killed by phylloxera...The Aramon roots of the suffering vines show numerous nodosities and tuberosities to almost the same extent as Vinifera vines. Why the Aramons should have collapsed so badly is not yet known. I am inclined to believe that a *new biological race of phylloxera* has evolved on Aramon roots in Helderberg, where Aramon has been the almost exclusive stock" (Perold's original emphasis.)

Alternative rootstocks

Many growers are concerned that alternative rootstocks will not be as productive as AXR#1 was prior to biotype B phylloxera. A re-examination of Lider's 1958 report tells a different story. While it was true that *on average* AXR#1's performance was superior, it was not the leading rootstock in every site. Table 1 summarizes the yield of all but one of the 17 trials reported (one trial was listed as a "mixed white variety"). It also shows the frequency of appearance of rootstocks in the trials. Some rootstocks, such as AXR#1, St. George, 1202C and 3309C, appeared in nearly all trials while others, such as 420A, appeared less frequently. Yields are calculated relative to that of AXR#1 (AXR#1 =100) for all scions. A second calculation of relative yield is also shown which includes only winegrape varieties popular in coastal areas today.

Table 1 bears out Lider's conclusion that AXR#1 was the most productive of all rootstocks examined; however, the differences were not great. For example, the rootstocks 110R and 420A yielded 90 and 95% of that of AXR#1, respectively. Furthermore, when only selected varieties are considered, the rootstocks 110R and 420A improved in relative yield, and a total of 6 rootstocks yielded from 84 to 107% that of AXR#1. The data clearly suggest that a shift to rootstocks other than AXR#1 need not require a great sacrifice in yield performance. In the second article, we examine the series of rootstock trials currently underway and draw initial conclusions where possible.

This review details the transition from the discovery of phylloxera to the use of "wild" rootstocks, to rootstock recommendations based on experimental trials. In the midst of our current transition to alternative rootstocks, one question persists: How could AXR#1 have survived in California through 50 years of trials by Husmann, Bioletti, Jacob and Lider? While the answer may ultimately lie in phylloxera's genetic diversity and the development of biotypes, surely a contributing factor was the enduring belief that growing conditions in California were significantly different from those in Europe. From the earliest literature on phylloxera, it was recognized that the life cycle of phylloxera in California was different from that in Europe. While the winged form was occasionally observed, no aerial leaf galls developed. Phylloxera in California apparently reproduced only asexually and the winged form did not contribute to spread.

Furthermore, from the early viticultural reports through the works of Bioletti, Husmann and Lider runs the tread of a belief, presumably based on a combination of experiment and experience, that phylloxera's ability to overcome resistant rootstocks was to a great degree dependent on soil type. So, rootstocks listed a susceptible to phylloxera on dry, shallow soils were nevertheless recommended for deep, alluvial soils well supplied with water. The list of rootstocks with a site specific phylloxera rating included AXR#1, 1202C and 93-5C, none of which would be recommended for use today.

In summary, some of the difficulties which plagued the early viticulturists are still with us today: the mechanism by which phylloxera kills grapevines is not fully known nor is the biochemical or genetic bases for a rootstock's resistance well understood. The consequences of this last point will be expanded upon in the final article. □

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No 1993-94 Raisin Diversion Program

In a late November meeting, the Raisin Administrative Committee reviewed the supply and demand situation for natural seedless raisins and approved a recommendation that no raisin diversion program would be announced and implemented for the 1993-94 crop year.

The projected supply and demand situation is reviewed at the end of November each year to determine the desirability of announcing a raisin diversion program. This is the third crop year during the last nine seasons when the raisin industry has agreed not to announce a diversion program.

"The RDP was a real liner this year, said Clyde Nef, manager of the Raisin Administrative Committee, Fresno. "We harvested a 380,681 ton crop, but our free tonnage was set at 282,909 tons. This gives us 97,000 tons in the reserve pool.

"Figuring that we need 40,000 tons for the export blend, our reserve pool drops to 57,000 tons and we're working we anticipate that the government will buy about 20,000 for the 1994 government program," said Nef. "Now we're theoretically down to 37,000 tons for the reserve pool."

Based on this year's movement, Nef said the industry should carry out 90,000 tons in free tonnage on Aug. 1, 1994.

Nef said that after the disasters in the '70s the industry has always wanted to carry out 150,000 tons. "If we have 90,000 tons in free tonnage then we need 60,000 tons for reserve to be on target.

"If we have a disaster, then the industry may laugh to the bank, but if we have another big yield then we'll take action next year to correct it.

"Our objective is to sell all we can sell, not to hold it all," said Nef. □