Summary 17

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Title: **"Grapevines below ground: Evaluating the root systems of multiple rootstocks at Oakville and Napa, California"**

By: Lisa Morano

Ph.D. Dissertation (Chapter 2). Department of Viticulture & Enology, University of California, Davis, pp. 38-101. 1995. **Unpublished.**

In this doctoral thesis project, the author acknowledges that the study of the grapevine's roots has been widely neglected. In the wake of massive replantings due to the phylloxera destruction of AXR1, her goal was to evaluate the root systems of several different rootstocks at two different locations. Additionally, she studies how two different vine spacings affect root behavior.

- To study the roots the author used a common method called "trench profile": trenches 2 meters deep are dug parallel to the vine rows with a backhoe, and the shoots intersecting the trench wall are recorded with the help of a 1m x 1m grid divided into 10 cm^2 squares. The author distinguished between density, distribution, and amount of roots. *Density* refers to the amount of roots per volume of soil –or per surface, since we are looking just at a plane. *Distribution* is the pattern the roots form on the grid. *Amount* is simply the total number of roots intersected, regardless of location. For recording purposes, the roots counted were divided into 4 size categories: small (<2mm), medium (2-5mm), large (2-12mm) and very large (>12mm).

- The trial took place at two locations. In Site 1, the UC Davis Experimental Station in Oakville, California, the author compared 6 rootstocks: 110R, O39-16, 3309C, 1616C, 5C, and 420A, all grafted to Cabernet Sauvignon. Additionally, she compared two in-row spacings, 1 meter and 2 meters, for each of these rootstocks. This site has N-S oriented rows and vines trained to a Scott-Henry trellis system. At Site 2, the Beringer Hudson Ranch in Napa, the author compared 7 rootstocks: the same as above plus 5BB, this time grafted to Chardonnay. Only one spacing (2m) was studied here. This site has E-W rows, vines trained to a VSP, and the presence of a cover crop – not present at Oakville. [*AxR#1 and 1202C were also studied but data is not presented as these rootstocks are no longer recommended*]

- **Soil types**. The soils of both trial sites were very different. The Oakville soil is a Bale gravelly clay loam, whereas the Beringer soil is a Coombs gravelly loam. The main differences between them consisted of 1) the percent gravel, 2) the depth of the water table, and 3) the oxidation-reduction status. The Oakville soil was more gravelly, had a shallower water table, and had lower redox potential, which is a sign of poor drainage. This was more pronounced on the lower east side. The most notable characteristic of the Oakville soil was its high variability. The Napa soil, in contrast, was very uniform. Its most relevant feature was the presence of an impenetrable layer at 1m of depth. Even though the subsoil here was heavier than at Oakville, the vineyard had been tile-drained before planting, so by comparison, the water table was lower, and the redox potential higher.

- **Effect of rootstock**. Rootstock had a significant influence on root density and the amount of roots in each size category. At Site 1 in Oakville, 420A was the rootstock with the fewest roots. At the opposite extreme, O39-16 had the largest roots. In fact, the ranking of rootstocks based on amount of large roots

was practically identical to that based on above-ground growth, as proposed by Kliewer in a previous work: in descending order by root size, 039-16, 110R, 1616C, 3309C,5C, and finally,420A. This order also correlated with pruning weights. As for the Beringer site, in Napa, 039-16 was also the rootstock with the most large size roots. Rootstocks 110R, 420A and 1616C all had fewer large roots. Unlike at Oakville, rootstocks at this site did not show a significant difference in the amount of small roots, probably due to the presence of an impenetrable clay layer at 1m of depth. The author notes that small and medium roots tend to be the most sensitive to changes in soil environment.

- The author found that the type of rootstock influenced how deep the roots developed. This is called **rootstock by depth interaction**. At Oakville, constant cultivation restricted root density at the 20-40 cm depth. At this site, there was a significant difference in root depth depending on rootstock. This was true mainly for medium size roots. The greatest difference was between the deeply-rooted 039-16 and the shallow-rooted 420A. Rootstocks 110R and 3309 (half *V. rupestris*) resembled the deeper distribution of O39-16, whereas 5C and 1616C (half *V. riparia*) resembled 420A. The author notes that crosses with *V. riparia* might possess a genetically disposition for shallow root system, or else be too weak to develop deep roots. At Napa, there was also an effect of depth on root distribution, but only for the large root size category. The cover crop present within the row in this vineyard reduced the amount of roots in the top 20 cm. However, this cover crop also seemed to improve soil structure, and allowed for distinct root proliferation at the next 20-40 cm horizon. Once again, the smaller effective depth of soil at this site will have affected the distribution of small and medium roots, hiding any potential differences among rootstocks.

- **Effect of vine spacing.** This effect was studied only at Oakville. At this site, the author found more small, medium, large and very large roots in the 2 m spacing than in the 1 m spacing. But the author also states that the closer spacing had a higher root density (# of roots intersected per m^2). The likely explanation is that the closer spacing caused the roots to be more concentrated in the smaller volume of soil, whereas many of the roots found in the 2 m spacing were further away from the trunk. These results agree with a previous author who found that closer spacing induced smaller root systems, but increased root densities. This same author also suggested that closer spacing might induce deeper root systems. In the current work, the author could not find any "vine space by depth" interaction, that is, the 1 m spacing did not cause the roots to go deeper.

- The author did find a large **rootstock by vine space interaction**, that is, the number of large roots at the 2 m vine spacing increased more with some rootstocks than it did with others. When given a larger volume to explore (2 m spacing), 110R, O39-16 and 3309C developed a larger number of large roots (were more aggressive), whereas 5C, 1616C and 420A had the same amount. Thus, the vigor of a particular rootstock depends not only on its soil environment, but on the proximity of other vines.

- **Effect of a high water table.** The difference in water tables between the well-drained (west) and the poorly drained (east) sides at Oakville allowed the author to compare its effect on root distribution. Overall, there were more small, medium and total roots in the drier side of the vineyard, on the west end. They attributed this to the fact that the higher water table on the east end was limiting root growth. Furthermore, the author found that rootstocks 3309C and 110R showed increased root density and increased vigor at the drier end, whereas 5C, 1616C and 420A did not show any enhanced growth. As we have seen, all of the rootstocks in the first group are half *V. rupestris*, so the author concludes that rootstocks with *V. rupestris* parentage may be better adapted to well-drained soils.

- **Effect of amount of gravel.** A previous author had shown that fine-textured soils have a higher density of roots than sandy soils because of the higher water holding capacity. So the current author studied the effect that variations in percent gravel would have in the distribution of roots. At Oakville, an increase in percent gravel was correlated with an increase in the number of roots at depths of 80 cm and below. Percent gravel at more shallow levels was fairly homogeneous and no correlations were observed. At Napa, with more homogeneous soil and root distribution limited below 1 m, no correlations between percent gravel and amount of roots were observed at any depths.

A few take-home messages:

- a higher spring water table (60-80cm) limited root growth
- a higher percent of gravel at deeper levels enhanced root growth
- frequent soil cultivation limited root growth in the top 20cm
- in-row cover crop limited root growth in the top 20cm, and enhanced root growth in the 20-40cm.
- closer vine spacing did not cause vines to establish a deeper root system
- 039-16, 3309C, AXR#1 and 110R (all half V. rupestris) are better adapted for well-drained soils.
- 5C, 1616C and 420A were less aggressive in establishing large roots at a wide spacing and would be easier to manage in close-spacing situations.
- 420A had the fewest and smallest roots and should be avoided in poor soils. 039-16 had the most and largest roots and should be avoided in vigorous situations.
- there is a correlation between rootstocks with the highest density of large roots, the deepest distribution of roots, and the greatest above-ground growth. So, what we see in above-ground growth does give us a clue of what is going on underground, after all!

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