EM 8882 • December 2004
$2.00

Grapevine Rootstocks for Oregon Vineyards

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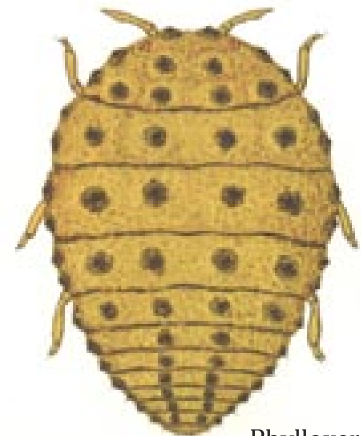

Phylloxera as depicted by the Swiss biologist and enologist Dr. Otto von Schneider-Orelli (1880–1965). Enlarged 66x.

Phylloxera: Why grafting to rootstocks is important

Grafting, which involves combining two different varieties or species to form a plant with new characteristics, is a technique known from ancient times in tree fruit and grape production. It was, however, used in viticulture only for certain special cases: to change variety, increase vigor, or increase limestone tolerance.

The principal reason for the increased use of grafting in viticulture was the phylloxera (*Daktulosphaira vitifoliae*) epidemic. Native to North America, phylloxera was inadvertently introduced into Europe around 1860. More than 4 million vineyard acres were destroyed by phylloxera before 1900.

Leo Laliman, a French wine grape grower, is credited with the idea of grafting European grape vines, *Vitis vinifera*, onto rootstocks from *Vitis* species of North American origin. Because these species coevolved with phylloxera, they developed resistance mechanisms that still are not completely understood.

Rootstocks have been bred from a number of Vitis species, especially *V. berlandieri, V. riparia*, and *V. rupestris*. Some common rootstocks and their parentage are shown in Figure 1 (page 2).

Phylloxera was introduced into California at about the same time as its introduction into Europe. It has since been found in every major viticultural region of the world, with the exception of Chile and parts of Australia.

In Oregon, phylloxera was first discovered at a commercial vineyard in 1990. It is estimated that the number of infested vineyards has doubled approximately every 2 years since then. In 2001, there were between 58 and 60 vineyards with confirmed phylloxera infestations. Because symptoms do not appear immediately, the actual number of infested vineyards probably is higher.

Proper sanitation may reduce the risk of phylloxera infestation (see OSU Extension publication EC 1463), but it is no guarantee against its spread. The potential economic loss from phylloxera infestation is so great that planting on resistant rootstocks is recommended even in regions where phylloxera is not yet present.

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Oregon State University Extension Service

Note that rootstocks with *V. vinifera* parentage do not provide adequate phylloxera resistance. The well-documented failure of AXR 1 (*V. vinifera* x *V. rupestris*) in California should serve as a warning to growers in other regions. Because French-American hybrids (e.g., Baco noir and Marachel Foch) have *V. vinifera* parentage, they should be grafted to resistant rootstocks.

Other reasons for using rootstocks

Aside from phylloxera resistance, rootstocks can be used to combat other soil-borne pests, primarily nematodes. Rootstocks also can increase vine performance in certain soil types and conditions such as wet or poorly drained soils, saline soils, and low or high pH soils. Similarly, rootstocks can impart greater drought tolerance to vines.

The use of rootstocks also may affect fruit and wine quality to such an extent that grafting is desirable even in the absence of the above-mentioned stresses. Rootstocks can have a direct effect on wine quality by influencing grape potassium content, anthocyanins, etc., or an indirect effect by controlling vigor, influencing fruit ripening time, and affecting berry size.

Nematode resistance

In some viticultural regions, such as parts of Australia, nematodes pose a greater threat to vine production than does phylloxera. In these regions, phylloxera resistance is secondary to nematode resistance when selecting rootstocks. Fortunately, some rootstocks provide resistance to both pests.

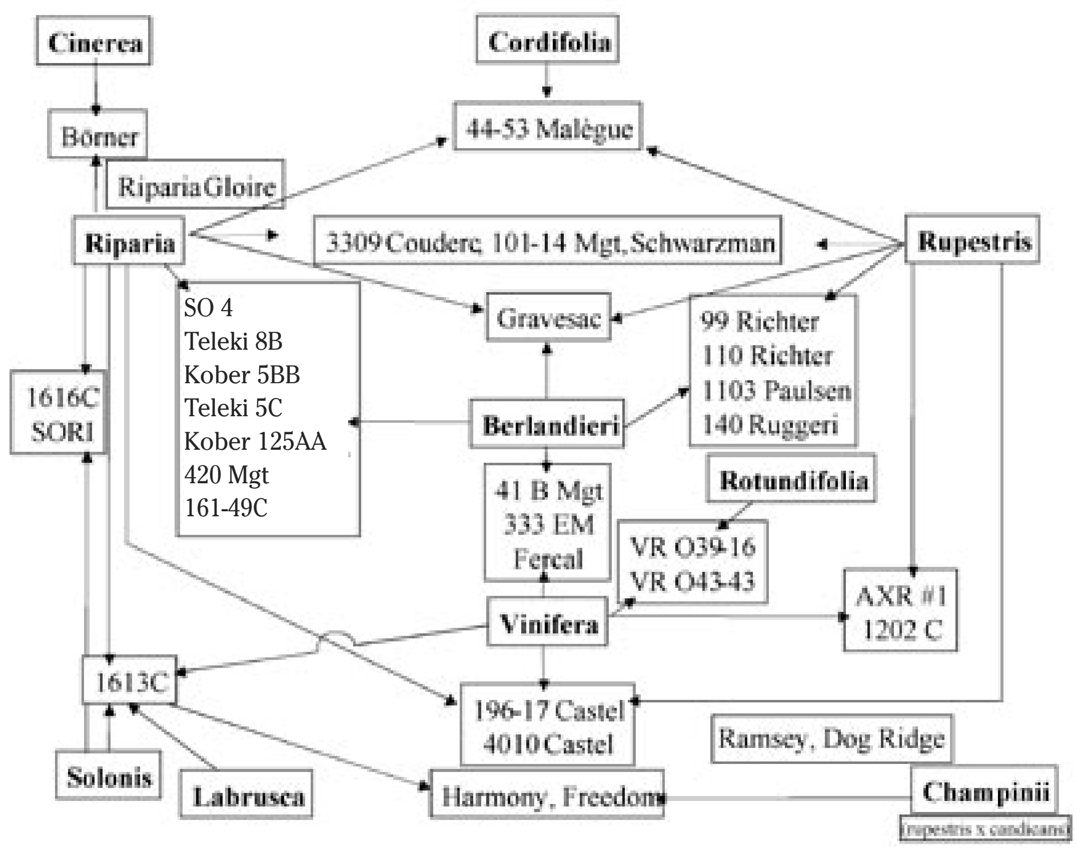


Figure 1. Common rootstocks and their parentage.

Nematodes are present in some Oregon vineyards at levels that would be destructive in other viticultural regions. Why they are not as destructive in Oregon is not completely understood. It may be that vines in Oregon vineyards are more vigorous than in other regions, allowing them to outgrow nematode damage or parasitism.

Pests such as nematodes and phylloxera may be more damaging when coupled with drought or nutritional stress. Nematodes also may hinder the growth of newly planted vines, particularly when replanting existing vineyard sites. Growers therefore may want to consider rootstock nematode resistance when soil tests indicate high population densities of plant-parasitic nematodes.

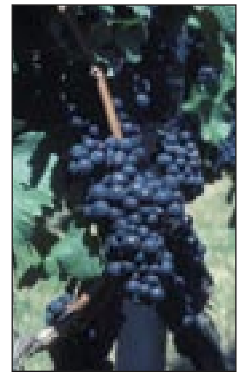
A common misconception is that a rootstock resistant to one type of nematode is resistant to all types of nematode. This is not the case. It therefore is important to know specifically which nematode species are present on your site.

In Oregon, the two major species of nematodes that pose a threat to grape vines are the ring nematode (*Mesocriconema xenoplax*) and the dagger nematode (*Xiphinema americanum*). It is important to make these distinctions when considering information from other viticultural regions about rootstock resistance to nematodes. For example, rootstocks that are resistant to other species of dagger nematode such as *Xiphinema index* may not be resistant to *Xiphinema americanum*.

Adaptation to different soil types

Some rootstocks are better suited to certain soil types than others. For example, some may perform better in sandy soils, while others do better in soils with a high clay content. High pH (basic) soils are not common in Oregon, and saline soils are more of a concern in arid regions that are highly dependent on irrigation. However, excessive soil moisture can be a problem on some sites in Oregon. Rootstocks that tolerate "wet feet" are preferred where drainage is poor or where soils tend to hold water.

Acidic (low pH) soils are common in Oregon, and liming to increase soil pH is a common practice at many vineyard sites. Rootstocks that tolerate acidic soils may reduce the need for liming at these sites.



Drought tolerance

Drought tolerance may not be as much of a concern in Oregon as in other viticultural regions. Nevertheless, the state's grape-growing areas receive less summer precipitation than most of the world's other viticultural regions, and signs of water stress can be observed during late summer in vineyards across the state. Rootstocks with some drought tolerance may be desirable at nonirrigated sites, particularly those with porous soils. This is especially true in the state's warmer, southern appellations.

Mineral nutrition

The mineral content of the scion (the wine grape variety grafted to the rootstock) is the combined result of the rootstock root system's ability to absorb nutrients and the scion's ability to translocate and accumulate them. Uptake efficiency of magnesium (Mg) and potassium (K) varies among rootstocks. Scion demand for these nutrients also varies with cultivar.

Choose cultivars and rootstocks with matching K and Mg uptake and use abilities. Varieties with high magnesium demand, such as Chasselas, Cabernet-Sauvignon, Merlot, Cardinal, Gewürztraminer, Ugni Blanc, Sauvignon Blanc, or Syrah, should not be grafted onto rootstocks susceptible to magnesium deficiency in soils with a poor supply of magnesium. Varieties with high potassium demand, such as Cabernet Sauvignon, Merlot, Aramon, Cinsaut,

Syrah, or Müller-Thurgau, should not be grafted to rootstocks prone to potassium deficiency if soil potassium levels are low. Fertilizer application should also take account of these differences.

Some recent research in Oregon suggests that nitrogen uptake is more efficient in vigorous rootstocks. Rootstock-induced variation in mineral content can be detected using both leaf petiole analysis and juice analysis. However, there is less variation in mineral content in the juice than in the leaf petioles; therefore, both should be used in the selection of efficient rootstocks.

Controlling vigor

Excessive vigor is associated with poor wine quality, poor fruit set, increased disease pressure, and delayed ripening. High vigor also makes it more difficult to maintain good vine balance, especially with the current trend in Oregon toward lower crop levels. Vine balance can be quantified as the ratio of fruit weight to the weight of pruned canes.

Controlling vigor can be difficult in Oregon vineyards, which often are on very fertile sites. Many Oregon growers feel that, next to phylloxera resistance, controlling vigor is the most desirable rootstock trait. Oregon's most widely used rootstocks are those that are known to be useful in controlling vigor.

As a general rule, in medium-fertility soils, graft vigorous varieties onto low- to moderate-vigor rootstocks and low-vigor varieties onto high- to moderate-vigor rootstocks. Where the soil is very fertile, avoid using vigorous rootstocks; the opposite is true for poor or shallow soils. In closely spaced vineyards, use low- to medium-vigor rootstocks; in widely spaced vineyards, use vigorous rootstocks. Double-curtain trellis systems require more vigorous rootstocks than single-curtain trellis systems.

Ripening time

The effect of rootstocks on fruit ripening is particularly important in cool-climate viticultural regions such as Oregon. In years when rain threatens during harvest, advancing fruit maturation by a few days may result in a significant economic benefit to the grower. Earlier ripening also may allow greater development of varietal character by allowing extended “hang time.”

Generally speaking, rootstocks that help control vigor also ripen fruit early. However, some higher vigor rootstocks also are believed to advance fruit maturation.

Choosing the right rootstocks

A large number of rootstocks are available to Oregon growers. Rootstocks perform differently depending on the scion variety, cultural practices, and environmental conditions. Because of this high degree of variability, you might select several rootstocks for use in different sections of a vineyard. Select rootstock with the following considerations in mind:

- Phylloxera resistance
- Site climate
- Scion variety
- Nematode pressure
- Soil type and conditions (fertility, pH, drainage)
- Desired fruit yield and quality
- Training system and vine spacing
- Water availability and planned irrigation regime

The following discussion of selected rootstocks is organized by parentage. All of the rootstocks included are thought to possess adequate phylloxera resistance for use in Oregon. The information also is summarized in Table 1. In preparing this summary, we have drawn from research conducted in Oregon and other viticultural areas around the world.

Table 1. Grapevine rootstock ratings.

Rootstock	Riparia Gloire	3309C	101-14 Mgt	Schwarzmann	420A Mgt	5BB	SO4	8B	5C	125AA	161-49C	99R	110R	1103P	140Ru	1616C	44-53 Malègue	Gravesac
Characteristic																		
Adaptability to shallow, dry, clay soil	1	3	2	1	3	2	1	—	3	3	1	2	4	3	3	1	2	2
Adaptability to deep silt or loam	1	1	1	2	1	1	1	—	3	2	1	3	3	3	3	2	3	3
Adaptability to deep, dry, sandy soil	2	2	2	3	2	1	1	—	1	1	2	2	3	3	4	2	2	3
Tolerance of water-logged soil	3	3	3	—	2	2	3	—	—	—	2	1	3	3	2	3	3	3
Tolerance of lime	1	1	1	—	3	3	2	2	2	4	3	2	2	2	2	1	1	3
Tolerance of acid soil	1	1	1	1	2	2	3	—	1	3	—	4	3	2	1	1	3	4
Nitrogen uptake	2	2	3	2	4	4	4	1	2	4	3	3	2	2	3	3	2	2
Vigor conveyed to vine	1	2	3	1	3	3	3	2	3	4	3	3	2	4	3	3	1	2
Drought tolerance	1	3	1	1	2	3	2	3	2	4	2	2	3	4	4	2	2	1
Resistance to ring nematode	2	1	4	2	4	2	2	2	2	—	—	2	3	1	2	—	2	1
Tendency to overbear	4	3	1	4	1	2	1	3	2	2	2	2	1	2	2	2	4	1
Vegetative cycle (time to ripening)	1	2	1	1	2	2	2	3	3	4	2	4	1	4	2	4	2	2

Legend

Vegetative cycle: 1= shortest; 4=longest

Nematode data: 1=highly susceptible; 2=susceptible; 3=moderately resistant; 4=resistant

All others: 1=lowest; 4=highest

From Galet; Howell; R. Jackson; Pongrácz; Taylor; Shaffer; McAuley; and Sampaio. Ring nematode (*Mesocriconema xenoplax*) data were collected in the Willamette Valley. Oregon information was collected from seven field trials, six of which had Pinot Noir as the only scion and one with Pinot Noir, Chardonnay, Merlot, and Pinot Gris in a factorial design. Nitrogen uptake was estimated by leaf greenness measurements on Pinot Noir in the Willamette Valley during 5 years.

V. riparia x *V. rupestris* crosses

This is by far the most popular family of rootstocks in Oregon, accounting for nearly 70 percent of the state's rootstock-planted acreage. These rootstocks are known for conferring low vigor and early ripening to grafted vines. They are not considered to be drought-tolerant.

3309 Coudrec (3309C) is the most widely used rootstock in Oregon, accounting for 38 percent of rootstock-planted acreage. In Oregon, as in Europe, 3309C imparts low to moderate vigor to grafted vines. Like other rootstocks in this group, it is thought to ripen fruit early. In Oregon, 3309C seems to delay ripening when cropped at higher levels.

Vines on this rootstock tend to overcrop and have a high yield-to-pruning ratio. It is recommended for varieties with poor fruit set. The high fruitfulness it induces may require crop adjustment.

3309C has a deep, well-branched root system. It is a good rootstock for deep, well-drained soils that are well-supplied with water. It has been reported to have poor drought tolerance elsewhere, but

V. riparia x *V. rupestris* crosses

3309 Coudrec

101-14 Millardet et De Grasset

Schwarzmann

in Oregon it showed average resistance to drought, and it was the most drought-tolerant rootstock within the *V. riparia* x *V. rupestris* family in trials in Oregon.

Plants have several strategies for protecting themselves from drought. Because the potential for transpiration from a small canopy is lower than that from a large canopy, one strategy is to limit canopy area. 3309C seems to restrict canopy leaf area to avoid excessive water loss by transpiration during the hottest part of the season. Other rootstocks cope with drought by using water more efficiently or by promoting root growth to maximize the soil volume available for mining water and nutrients.

3309C is not suited to dry, shallow, or compacted soils. It has a tendency to induce potassium deficiency, particularly in overcropped young vines on clay soils. It is susceptible to both dagger and ring nematodes.

101-14 Millardet et De Grasset (101-14 Mgt) is Oregon's second most widely used rootstock, accounting for 30 percent of rootstock-planted acreage.

101-14 Mgt is reported to be a less vigorous rootstock than 3309C. However, it has demonstrated higher vigor on some sites in Oregon, especially those where water is not limiting. It is the most vigorous of the *V. riparia* x *V. rupestris* group. Unlike 3309C, it induces low yield-to-pruning ratios. It has imparted early ripening in trials in Oregon.

101-14 Mgt has a fairly shallow, well-branched root system and is best suited to moist, deep soils. It is a good rootstock for clay soils, even if they are poorly drained. It has poor drought tolerance and is not recommended for nonirrigated sites with well-drained soils. It is sensitive to low pH and should not be used in acid soils without first applying lime. It is highly resistant to the ring nematode. In South Africa, it shows lack of compatibility with some varieties, such as Syrah and Chardonnay.

Schwarzmann is not widely used in Oregon, although it is in the same family as 3309C and 101-14 Mgt. In Australia, Schwarzmann is believed to impart moderate vigor. However, in Oregon, it imparts low vigor and has a strong tendency to overcrop. In an irrigated trial in Oregon, Schwarzmann was less vigorous than 101-14 Mgt and 3309C. Scwarzmann ripens fruit early. Like other members of this family of rootstocks, it improves fruit set.

Schwarzmann is recommended for a variety of soil types in New Zealand, with the possible exception of heavy clay soils. In Australia, it reportedly performs best on moist, deep soils and is considered to be more drought-tolerant than both 3309C and 101-14 Mgt. However, in Oregon its drought tolerance was as low as that of Riparia Gloire, and it was the least drought-tolerant of the group. It should not be used on dry soils without irrigation. It seems to be susceptible to ring and dagger nematodes.

V. riparia

Riparia Gloire is the third most widely used rootstock in Oregon. It is known primarily for imparting very low vigor and therefore is a good choice for fertile sites where a very low yield is desired. Riparia Gloire advances ripening and induces very high yield-to-pruning ratios. It has a very

V. riparia
Riparia Gloire

short growing cycle, typically inducing leaf senescence and leaf fall earlier than other rootstocks.

Riparia Gloire has a shallow-growing, well-branched root system. It is suited only to deep, moist, fertile soils. It has very poor drought tolerance and should not be used in well-drained soils without irrigation. Fruit must be thinned from vines grafted to this rootstock, or vigor will decline through a strong tendency to overbear. It is susceptible to ring nematode.

V. berlandieri x *V. riparia* crosses

These rootstocks have performed well in other cool-climate viticultural regions, suggesting that they might be good choices for Oregon. As a family, they are the second most widely used in Oregon, accounting for approximately 11 percent of rootstock-planted acreage.

Selection Oppenheim Nr. 4 (SO4) is the most widely used *V. berlandieri* x *V. riparia* rootstock in Oregon. It is a moderate to vigorous rootstock. In Germany, South Africa, and New Zealand, it is thought to advance ripening. In France, however, it seems to delay ripening. In Oregon, SO4 has had no impact on timing of fruit maturation.

Available information on SO4's effect on fruit set also is conflicting. Germany, South Africa, and New Zealand report it to be especially suited for varieties with poor set. In France, its excessive vigor is reported to cause poor fruit set. In Oregon, we observed a slight reduction in fruit set. It tends to induce low yield-to-pruning ratios.

SO4 has a shallow root system and performs satisfactorily in acid soils. It does best in light, well-drained soils of low fertility. It is suited to humid soils but not recommended for dry conditions, although in New Zealand it is reported to be drought-tolerant. Do not graft varieties with high magnesium demand onto S04 because they tend to show symptoms of magnesium deficiency and inflorescence necrosis. SO4 develops slowly and shows low vigor in the first years of development, but vigor increases significantly thereafter. SO4 is susceptible to ring nematode.

Couderc 161-49 (161-49C) is not used to a large extent in Oregon. Trials here indicate that it may be well suited to some sites in the state. 161-49C is a moderate to vigorous rootstock with pruning weights very similar to SO4 and slightly lower than 420A Mgt, 5BB, and 5C. In an Oregon trial, it performed very similarly to SO4 in terms of fruit composition, drought tolerance, and vine size, while inducing better fruit set and more balanced yield-to-pruning ratios. It has a shallow root system and is not well suited to dry, non-irrigated soils.

Teleki 8B (8B) is a low- to moderate-vigor rootstock. In Oregon, 8B has been less vigorous than other *V. berlandieri* x *V. riparia* rootstocks. Ripening is neither delayed nor advanced by this rootstock. Fruit set is good in fertile soils. However, 8B is not appropriate for high-yielding varieties.

This rootstock has a shallow root system and is not appropriate for shallow, dry soils. Its drought tolerance is intermediate between SO4 and 5BB. It has low nitrogen uptake efficiency and is susceptible to ring nematode. Overall, this rootstock did not perform as well as others in this family.

Kober 5BB (5BB) is thought to be a vigorous rootstock. In Oregon, it is less vigorous than 125AA and is similar in vigor to SO4, 5C, 420A, and 161-49C. Ripening is delayed by the higher vigor of this rootstock. It can cause imperfect fruit set on vigorous varieties and in fertile soils. It tends to induce low yield-to-pruning ratios.

5BB has a shallow-growing root system. It is one of the best rootstocks for humid, compacted, calcareous soils. It also has above-average drought tolerance. 5BB is not suitable for

V berlandieri x *V. riparia* crosses

Oppenheim Nr. 4

Couderc 161-49

Teleki 8B

Kober 5BB

Teleki 5C

Kober 125AA

420A Millardet et De Grasset

high-yielding varieties due to poor potassium uptake. 5BB is susceptible to the ring nematode. In California, it is reported to be sensitive to phytophthora and is not recommended for sites likely to have standing water. It is not suited for sites that are affected by severe winter cold.

Teleki 5C (5C) is a moderate to vigorous rootstock. Its vigor is intermediate between 5BB and SO4. It tends to have a low yield-to-pruning ratio. It is well suited for varieties with poor fruit set. It is suitable for well-drained, fertile soils and is a good choice for heavy soils (clays and clay loam). It has low drought resistance, comparable to that of 101-14 Mgt and 420A Mgt. It is susceptible to both ring and dagger nematodes.

Kober 125AA (125AA) is a vigorous rootstock. In a trial in Oregon, it was the most vigorous among 20 rootstocks. It also was one of the most productive and latest ripening. It is not appropriate for varieties with irregular set because its vigorous growth can cause poor fruit set. It is best suited to high-yielding varieties such as Müller-Thurgau.

125AA is the most drought-tolerant of this group. In Germany, it is recommended for a wide range of soils, particularly heavy, compact soils with poor aeration and drainage. In New Zealand, however, it is recommended for poor, stony soils. It establishes slowly.

420A Millardet et De Grasset (420A Mgt) is reported to be a low- to moderate-vigor rootstock. In Oregon, however, 420A Mgt has been a moderate- to high-vigor rootstock, slightly more vigorous than 5BB. It improves fruit set. Its ripening period coincides with that of 5BB. It tends to induce low yield-to-pruning ratios.

Its root system is fairly shallow-growing and well branched. It is well suited to poorer, heavy-texture soils. Italian and Australian sources report that 420A Mgt is a good rootstock for dry hillside sites. In contrast, French and South African sources report that 420A Mgt is susceptible to drought. In Oregon, it showed poor drought tolerance, similar to 5C. It does not withstand waterlogging. 420A Mgt is prone to induce potassium deficiency but is highly resistant to the ring nematode.

V. berlandieri x *V. rupestris* crosses

These crosses constitute the third major family of rootstocks and are used only to a very small degree in Oregon. They are best known for their drought tolerance. In Oregon, they may be best suited to nonirrigated, well-drained sites in the state's southern and eastern appellations.

99 Richter (99R) is a vigorous rootstock. The high vigor delays ripening.

The root system of 99R is very strongly developed and very deep growing. It is well suited to a wide range of soils, but wet, poorly drained sites should be avoided. Its drought tolerance is lower than that of 110R, 1103P, and 140Ru. It performs well in acid soils but assimilates magnesium poorly. In South Africa, it is considered to be the best rootstock for deep, fertile soils under irrigation. It is susceptible to ring nematode.

110 Richter (110R) is reported to be moderately vigorous to vigorous. However, in Oregon 110R has been a low- to moderate-vigor rootstock. This may be because initial vine growth is slow. It is not appropriate for varieties with irregular fruit set. It is reported to have a very long vegetative cycle, which delays maturity. In Oregon, with lower vigor, it ripens fruit earlier than other rootstocks in this family, and simultaneously with 101-14 Mgt, Schwarzmann, and Riparia Gloire.

Its roots are not as deep growing as those of 99R. It is well suited to all kinds of soils, including acid soils. It is an excellent rootstock in warm grape-growing

V berlandieri x *V. ruprestris* crosses

99 Richter

110 Richter

1103 Paulsen

140 Ruggeri

areas with an arid climate. Resistance to drought is superior to 99R, and it does well on poorly drained, shallow clays. It is a good rootstock for slopes or dry-farmed sites. It assimilates magnesium and potassium poorly. 110R has moderate resistance to ring nematode.

1103 Paulsen (1103P) is a very vigorous rootstock. It has a long vegetative cycle and delays ripening. Its root system is deep growing and strongly developed, and it is adapted to a wide range of soil conditions. It is more drought-tolerant than 99R and 110R. It assimilates potassium poorly and is highly susceptible to ring nematodes.

140 Ruggeri (140Ru) is reported in some countries to be a vigorous rootstock with a long vegetative cycle and delayed maturity. However, these traits have not been observed in trials in Oregon and Switzerland, where it is a moderate-vigor rootstock and ripens fruit simultaneously with 3309C.

The root system is very deep growing and well branched. It is not recommended for deep, fertile soils that are well supplied with water. However, it performs well in shallow, dry, calcareous soils and well-drained deep soils. It is very drought-tolerant. It is not well-adapted to very acidic soils, but does well at pH 5 or above. Like 1103P, it assimilates potassium poorly. It is susceptible to ring nematode.

V. riparia x *V. solonis* crosses

1616 Coudrec (1616C) is supposedly a moderately vigorous rootstock. However, in both Oregon and California, 1616C is a vigorous rootstock. Fruit set is improved by this rootstock. It has a long vegetative cycle and delays ripening. It has a shallow, well-branched root system. It is sensitive to drought and best adapted to fertile, humid, poorly drained soils. It grows poorly in infertile and sandy soils.

Complex crosses

V. cordifolia x *V. riparia* x *V. rupestris* crosses

44-53 Malègue (44-53M) is a low- to moderate-vigor rootstock that improves fruit set and advances maturity. This rootstock has a tendency to overbear, and fruit thinning may be required.

Its root system is deep growing and very strongly developed. It assimilates potassium well, but often suffers from magnesium deficiency. As a result, it is used primarily in California on sites with low levels of soil potassium and high levels of soil magnesium. It also is used on the acid soils of the eastern Pyrenees. It is susceptible to the ring nematode.

V. riparia x *V. berlandieri* x *V. rupestris* crosses

Gravesac is a newer rootstock, bred especially for acid soils. Until recently, it was not available in Oregon. Initial tests indicate it could be successful here. It is a low- to moderate-vigor rootstock that advances ripening. It is adapted to a wide range of soils, provided they are well-supplied with water. It is highly susceptible to ring nematode.

***V. riparia* x *V. solonis* cross**
1616 Coudrec

Complex crosses
44-53 Malègue

Gravesac

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Further reading

Galet, P. 1998. *Grape Varieties and Rootstock Varieties*. Oenoplurimédia, Chaintré, France.

Howell, G.S. 1987. *Vitis* rootstocks. In: *Rootstocks for Fruit Crops*. R.C. Rom and R.B. Carlson (eds.). John Wiley & Sons, Inc., New York. pp. 451–472.

Jackson D. and D. Schuster. 2001. *The Production of Grapes and Wine in Cool Climates*. Daphne Brasell Associates LTD and Gypsum Press, Wellington, New Zealand.

Jackson, R.S. 2000. *Wine Science: Principles, Practice and Perception*. 2nd ed. Academic Press, San Diego.

McAuley, M.D. 2004. Rootstock Effect on the *Vitis vinifera* Cultivars Pinot Noir, Chardonnay, Pinot Gris, and Merlot During Establishment. MS Thesis, Oregon State University, Corvallis.

McKenry, M.V., J.O. Kretsch and S.A. Anwar. 2001. Interactions of selected rootstocks with ectoparasitic nematodes. *Am J Enol Vitic.* 52:4.

Pongrácz, D.P. 1983. *Rootstocks for Grapevines*. David Philip, Cape Town, South Africa.

Sampaio, T.L. 2003. Evaluation of viticultural characteristics of phylloxera resistant rootstocks for the cultivars Pinot Noir, Chardonnay, Pinot Gris, and Merlot. In *Proceedings of the 12th Annual Conference of the Northwest Center for Small Fruits Research*. Kennewick, WA, Dec 4, 2003. pp. 69–73.

Shaffer, R.G. 2002. The Effect of Rootstock on the Performance of the *Vitis vinifera* Cultivars Pinot Noir, Chardonnay, Pinot Gris, and Merlot. MS Thesis, Oregon State University, Corvallis.

Strik, B. et al. 1995. *Phylloxera: Strategies for Management in Oregon's Vineyards*. Publication EC 1463. Oregon State University Extension Service, Corvallis. See ordering information at left.

Taylor, P. 2002. Evaluation of *Vitis* Rootstocks for Tolerance to Low Soil pH. MS Thesis, Oregon State University, Corvallis.

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Published December 2004