



Phylloxera

Strategies for management
in Oregon's vineyards



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Phylloxera: What is it?

B. Strik, A. Connelly, and G. Fisher

History

The grape phylloxera, *Daktulosphaira vitifoliae* (Fitch), is an aphidlike insect that feeds on grape roots. Phylloxera are native to the eastern and southern United States. The pest was inadvertently introduced to France from North America in 1860, and by the end of the century had destroyed two-thirds of the vineyards in Europe, all self-rooted *Vitis vinifera*. Since then, phylloxera have invaded most grape-growing areas of the world; for example, New Zealand, Australia, and South Africa.

They were introduced into California in the 1850s from the eastern United States. Phylloxera were identified in the Penticton area of British Columbia in 1961 and, in 1988, in eight sites in Washington state, one of which was a *V. vinifera* vineyard.

Phylloxera also were discovered in Oregon about 20 years ago. However, it was not until 1990 that this pest was discovered for the first time in modern commercial vineyards. Phylloxera now are in every major grape-producing region in Oregon. In 1995, 13 infested vineyards were identified; probably many more are infested in the state.

Description and life cycle

All adults are female. They are very difficult to detect because they are extremely small—0.7 to 1 millimeter ($1/30$ to $1/25$ inch) long and 0.4 to 0.6 millimeter wide (see Chapter 3, “Sampling vines to confirm the presence of phylloxera”).

Color of the adults varies with the food supply. On fresh vigorous roots, they are pale green, yellowish-green, olive

green, or light brown; on weakened roots they are brown or orange. Mature adults become brown or purplish-brown, no matter on what kind of root they have fed.

Each female can lay as many as 400 eggs. Newly deposited eggs are lemon yellow, oval, 0.5 to 0.7 mm long, and about half as wide.

The pest's rate of development depends on the grape root and vine phenology as well as on numerous environmental factors, including soil and air temperature and humidity.

Phylloxera overwinter on roots as small, dark nymphs (hibernants). In the spring, when soil temperatures exceed a critical level (from our research, that can be between about 45 and 65°F) and vine sap starts to flow, the nymphs begin feeding and then molt to adulthood. The mature forms deposit eggs by asexual reproduction. In Oregon vineyards, two to three generations a year have been seen, the first eggs in June.

Phylloxera are most numerous in late summer to early fall. Thus, they are easiest to detect then by digging up grape roots—and the risk of spreading the insect also is the greatest then (see Chapter 2, “Reducing the risk of phylloxera infestation”).

Newly hatched nymphs usually leave the roots where they were hatched only if a high phylloxera population has created feeding competition or when a vine is near death. These “crawlers” travel on the soil surface or in cracks in the soil, or they can climb the vine and be blown by the wind for considerable

distances. In Oregon, above-ground nymphs have been detected on trunk wraps in July and August.

In summer, possibly due to environmental or population conditions, some nymphs may develop wing pads and emerge from the ground as winged adult females (alates). The females usually fly to an upright surface such as the vine's trunk. They lay male and female eggs,

which hatch into male and female phylloxera that have no mouth parts—and thus do not directly damage the grape-vines—but can and do mate.

The female lays a large egg that overwinters probably in crevices on the trunk. This egg hatches into a female who feeds on the leaves of susceptible grape varieties, creating a leaf gall. She lays eggs that produce a population of nymphs, which can reinfest the root system or other leaves.

At the end of September, nymphs begin to hibernate, and by mid-December all forms are hibernants.

The winged, or sexual, stage of phylloxera has been found in Oregon, caught on sticky trunk wraps in July and August. It is not known whether winged phylloxera can complete their life cycle on European wine grapes. If they can, the pest's rate of spread will increase dramatically. However, we do know that the winged form can complete its life cycle on the foliage of American grapes such as ‘Concord’ or a rootstock or on the foliage of French-American hybrids such as ‘Marechal Foch.’

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Injury

Phylloxera damage *Vinifera* grapevines mainly by inhabiting and feeding on roots. It is believed that, when feeding, phylloxera inject poisonous saliva that causes roots to swell. Feeding generally is on the tips of the rootlets, causing yellowish-brown, hook-shaped swellings or galls (nodosities) to form. These may curve and bulge around the insect's body. In most cases, the swelling stops rootlet growth, and the infested portion eventually dies. Feeding on larger roots causes rounded swellings (tuberosities), which give the root a warty appearance. The tuberosities also may decay, further weakening the vine.

Root injuries impair the absorption of nutrients and water, causing a decline in vine vigor and productivity. Secondary fungal infection and the feeding of other insects and mites also hastens decomposition of roots.

Injury to the above-ground portion of the vine is an indirect result of root damage. Thus, the symptoms are similar to those of other pest problems such as *Armillaria* (oak root fungus), gopher damage, or nematodes (which also may cause similar root symptoms) and to symptoms of environmental problems such as severe water stress and winter injury.

The severity of the infestation may differ because of the variety of grape, the vine's age and vigor, soil condition, and drainage.

Vigorous vines resist phylloxera attack better than do

weak ones. Differences in vine vigor can be due to site differences, but also to varietal differences.

Infested vines live longer in fertile, deep, well-drained soil than in shallow soil or soil with poor drainage. Vines growing in heavy, shallow soils appear to succumb to the infestation most rapidly. Fine-textured soils, such as

There is no way to eradicate phylloxera in an infested, susceptible vineyard.

clay, generally are more favorable to infestation than light sandy soils, which appear to be almost immune to phylloxera. Heavier soils contract and crack when drying, and these openings allow the insect to crawl to and infest root systems.

Rate of spread in Oregon has ranged from nearly 2x (the infestation's doubling in size annually) to 10x on a site where the pest came in on infested plant material. Managing an infested vineyard, therefore, is a challenge (see Chapter 5, "Managing a phylloxera-infested vineyard").

There is no way to eradicate phylloxera in an infested, susceptible vineyard. The only method of control is to plant vines grafted to a resistant rootstock (see Chapter 7, "Phylloxera-resistant rootstocks for grapevines").

Chapter 2

Reducing the risk of phylloxera infestation

E. Hellman and B. Watson

Phylloxera can be spread from vineyard to vineyard on soil or root pieces carried by workers' boots, picking totes, vehicle tires, and other means. Infested soil also could be exchanged among vineyards at the winery via picking bins during the hectic activities of harvest delivery and crush. Therefore, both vineyards and wineries should take precautions against the movement of potentially infested soil.

Prevention is one of the few weapons for combating phylloxera.

Prevention primarily means restricting movement of people, equipment, and materials among vineyards and thoroughly cleaning all items that come in contact with vineyard soil.

All vineyards should be considered potentially phylloxerated. Even grafted vines on resistant rootstocks

can support populations of phylloxera and serve as a source of new infestations. A phylloxera infestation usually is not diagnosed until several years after its introduction into the vineyard. Therefore, controlled access and sanitation procedures are important for *all* vineyards and wineries. We recommend vineyards and wineries follow these procedures to reduce the risk of spreading phylloxera.

In the vineyard

Make every effort to restrict the movement of people and equipment in and out of the vineyard.

Restricted movement

- Control access to your vineyard. Do not allow entry without your approval.
- Do not share tractors, trucks, trailers, or other field equipment with another vineyard.
- Imprint the name of your vineyard on your picking totes and bins; accept only returned containers with your name.
- Do not share picking totes or bins with other vineyards or wineries.
- Load and unload trucks outside the vineyard on a paved or graveled road. Where possible, load grapes into bins or totes outside the vineyard rows so that the bottoms of the containers do not pick up soil.
- Bin or tote design should minimize the possibility of transporting soil; for example, avoid bins with a waffle pattern on the bottom. Containers should be easy to clean.

When that is not feasible, be especially thorough with your sanitation practices.

Sanitation

- Establish the vineyard with clean, phylloxera-free grapevines.
- Develop a set of standard sanitation practices for your vineyard, and instruct all workers.
- Establish a sanitation station for people to put on or clean their boots before entering and leaving your vineyard. The station should include "loaner" rubber boots and a tub containing a 10 percent bleach solution to sanitize boots.
- Thoroughly clean trucks delivering grapes to the winery before the trucks leave the vineyard. Use a 10 percent bleach solution or hot pressure washer with detergent.
- Thoroughly clean all equipment, totes, and other items before they leave the vineyard and again before they re-enter the vineyard. Use a 10 percent bleach solution or hot pressure washer with detergent.

At the winery

Restricted movement

- Restrict all vehicles to paved areas.
- Inspect all vehicles for cleanliness prior to entry.
- Restrict delivery trucks to a sanitation pad.
- Keep picking totes and bins separate for each vineyard.
- Do not share picking totes or bins with other vineyards or wineries.

Sanitation

- Establish a concrete sanitation pad for delivery trucks. Wash down the pad daily during harvest, using a 10 percent bleach solution or a hot pressure washer with detergent.
- Require that all vehicles, totes, bins, and other items be cleaned at the originating vineyard prior to delivery.
- Scrub picking totes and bins before returning them to the vineyard.

Chapter 3

Sampling vines to confirm the presence of phylloxera

B. Strik and G. Fisher

Grape phylloxera's feeding weakens the grapevine's root system, causing above-ground symptoms of weakened vine growth. These symptoms usually appear first as a lens-shaped, weakened area in the vineyard. However, if phylloxera were brought in on self-rooted (nongrafted) planting material, the whole vineyard block might appear generally weakened. As the phylloxera spread, the lens-shaped weak areas increase in size, and other areas of infestation may appear.

To find phylloxera in the winged, or sexual, stage of their life cycle in July and August, look for leaf galls on susceptible vines—not brown or white fuzz on the leaf bottom like that produced by erineum mites but light green galls on the underside of the leaf. *V. vinifera* are not susceptible to the leaf-feeding form of the pest (see Chapter 1, "Phylloxera: What is it?").

Finding grape phylloxera on infested roots is very difficult, especially in the early stages of an infestation. We have sampled weak areas in vineyards for 2 consecutive years without finding phylloxera, only to find them in the third year. Therefore, you should dig roots in suspected weak areas over repeated years. It may take from 2 to 5 years from initial infestation, depending on vine vigor and how the vineyard was infested, for the above-ground symptoms to show.

Keep in mind that there may be other causes for weak areas in a vineyard:

- Shallow soil or drought. Unlike a phylloxera-infested area, however, usually the weak area doesn't spread annually.

- *Armillaria* or oak root fungus. The weak area is circular and related to an oak tree on site prior to planting or adjacent to the vineyard block.
- Nematodes. The weak area is not necessarily circular. Sample for nematodes.
- Gophers. Damage is more random than from other causes.

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When and where to sample

The best time to sample for phylloxera is when populations are at their peak, from late July through harvest.

Phylloxera reproduce most successfully on healthy root systems; dead and weakened vines often have very low populations on the roots. When you sample for a suspected phylloxera infestation in your vineyard, it's best to look for the pest at the border of the damaged area, on vines just showing the first signs of decline. Most phylloxera are present on roots in the upper 1 to 4 feet of the soil, so this is the best place to sample. We have had the greatest success collecting root samples within 1.5 feet of the trunk.

Sample as many suspect vines as possible. A sample should consist of a pint to a quart of roots and associated soil (soil that is stuck to the roots) for each vine. Samples should include a portion of a larger root (about 0.5 inch in diameter) as well as feeder roots. Remove roots and associated soil

carefully, immediately putting them in a sealed container.

Inspect new fleshy growth on fine, feeder roots for nodosities (small swellings), which are symptoms of phylloxera feeding. Root tips infested with phylloxera are club-shaped or form hooks. Nodosities

may be yellow, turning brown later on. After root death, they will wither and decay, becoming impossible to detect. Be aware that swellings on feeder roots also may be caused by nematodes; however, to a trained eye such swellings look different than those caused by phylloxera.

Often tuberosities (large swellings) can be seen on older, thicker roots. However, phylloxera often are difficult to detect in advanced stages of an infestation as roots become dry or spongy.

The feeder roots often show nodosities, but actual colonies of phylloxera are more prevalent on larger, thicker roots. If these colonies contain numerous phylloxera, they appear as yellow spots on the root. Often, phylloxera are found under sloughing bark or in cracks of the root.

Identification

Because phylloxera are extremely small, use a 10x hand lens, or preferably a dissecting scope, to identify the pest. If you need help, please contact your county office of the OSU Extension Service. Finding *one* phylloxera when sampling is enough to verify an infestation.

Chapter 4

How to monitor the rate of spread of phylloxera in your vineyard

B. Strik, G. Fisher, and A. Connelly

Once you know your vineyard is infested, you should monitor rate of spread and decline in production to estimate how long the vineyard will remain productive. You also should consider how (or whether) to make the transition to a resistant or grafted vineyard (see Chapter 6, "Replanting options for establishing phylloxera-resistant vineyards").

Monitoring rate of spread within your vineyard means recording the rate and direction of spread of above-ground

symptoms—not of the phylloxera themselves—because infestations on roots can be difficult to see. Keep in mind that once an infested site is confirmed,

the phylloxera likely will have spread in a much wider area than is evident from the above-ground symptoms. This is because it takes a while for populations to build to the level that the vine is stressed and vigor is reduced. The insect already may be in the entire block or vineyard, although symptoms may show first in naturally weaker areas of the vineyard.

The following methods can be used to estimate rate of spread of above-ground symptoms.

Counting affected vines

Infestations often appear first as a lens-shaped area of weak vines. The easiest, but least accurate, way to estimate rate of spread is to count the number of

vines assumed to be infested within each lens. Do this in the fall just before or just after harvest when symptoms are most apparent. Phylloxera-infested vines that are succumbing to high feeding pressure will show reduced vigor and lighter green foliage. Often infested vines drop their leaves earlier than healthy vines, or the foliage yellows more quickly. However, other factors such as other pests, nutritional imbalances, or drought can cause similar symptoms.

Annually counting the number of affected vines will give you a rough estimate of the economic rate of spread (that is, the rate that the non- or low-producing area is increasing).

Subtract the number of vines affected last year from the number affected in the current year and divide by the number affected last year. This will give you the percent increase in size. For example, if 50 vines show reduced vigor this year and 20 did last year, the rate of spread would be:

$$(50-20)/20 = 1.5$$

or a 1.5x (150 percent) rate of spread.

Doing this for a few years will give you an idea of how quickly the vineyard will succumb to the infestation. In Oregon, we've seen rate of spread vary from 1.5x in an older vineyard (from a point-source infestation, such as from infested dirt on a boot or picking bucket) to 10x in a 7-year-old vineyard where phylloxera were introduced on the plant material.

Look out for "satellite" infestations—new areas of infestation that are separate from the initial finding. This is typical in infested vineyards because weaker vines succumb to infestations faster than more vigorous ones.

Vigor ratings

This is a modification of the counting system described above and can be more accurate if the same person rates vine vigor each year. Document the size of the declining area(s) in your vineyard by counting the number of dead vines and giving a vigor rating to the affected vines in the area (for example, 1 = healthy; 2 = mildly stunted or reduced growth; 3 = severely stunted; 4 = dead). Map the area on graph paper to keep accurate records.

A modification of this system is to keep records of pruning weights in vineyard blocks or affected areas. As vine vigor declines due to infestation, pruning weight also should decline. Monitor pruning weight and yield per vine in one or two long, narrow areas (transects) running through an infested area. The data will tell you a lot about rate of spread of phylloxera and its economic impact.

Aerial photography

This is the most accurate method for evaluating vine decline in the vineyard. It also is the only method that can be used effectively to monitor rate of spread within a region. Many growers

find that photographs taken every 2 to 3 years are adequate to detect vineyard problems and phylloxera spread.

Weak areas are easily spotted from the air and can be inspected with follow-up ground surveys to determine the possible reasons for vine decline. (Remember, however, that not all weak areas in vineyards are due to

phylloxera infestation.) Obviously, the photographic resolution and altitude at which the vineyard is photographed will determine the minimum size of weak areas to be detected (for example, 1 vine or 10).

Infrared aerial photography is superior for detecting changes in vine vigor. Healthy vines show up as bright or

dark red; weak and declining areas show up as lighter shades of red or not red at all. (Keep in mind that healthy weeds or cover crops also show as dark red.) Weak areas due to shallow soils usually will not enlarge in size annually unless erosion is occurring.

Chapter 5

Managing a phylloxera-infested vineyard

E. Hellman

Phylloxera infestation in a self-rooted European winegrape (*Vitis vinifera*) vineyard is considered to be ultimately lethal to the grapevines. The severity of infestation and progression of damage to vines, however, can differ among vineyards because of local site conditions and management practices.

Vigorous vines tolerate phylloxera feeding better than weaker vines; therefore, conditions that promote vigor, such as deep, fertile soils and irrigation, may enable infested vines to live longer.

Prolonging the productive lifespan of infested vines is one management approach for dealing with phylloxera. Another approach is to slow the spread of infestation within the vineyard by altering management practices. You should use both approaches, but eventually you will have to make a decision on how long to retain the infested vineyard and when or whether to replant with vines grafted to a resistant rootstock (see Chapter 6, "Replanting options for establishing phylloxera-resistant vineyards").

Prolonging vine lifespan

Infested vines that are otherwise healthy and unstressed are better able to tolerate phylloxera feeding than low-vigor or stressed vines. Be sure to keep crop production in balance with the vigor of the vines. Overcropping is

a severe stress to the vine. It also is important to maintain or improve your weed and pest management practices to prevent these stress factors from contributing to the decline of the vine. You also may consider a fertilization program to enhance vigor.

Irrigating infested vines to avoid water stress is an important tool for maintaining vigor. If irrigation is not possible, water availability can be increased by removing between-row groundcovers or replanting with a groundcover that is less competitive.

Maintaining a clean, tilled vineyard, however, has several drawbacks, including a tendency to increase the spread of phylloxera by tilling, especially by tilling after May.

Although your first impulse upon discovering phylloxera in your vineyard may be to pull out the visibly damaged vines, this practice does not eliminate phylloxera from the vineyard. In fact, it tends to enhance its rate of spread.

It is better to leave infested vines in the ground for as long as they are economically productive, managing them as described below. Remember that symptoms of phylloxera damage take several years to develop, and that the infestation is not likely to be limited to the area where they have been found. Furthermore, it is not feasible to remove the entire root system when

pulling vines; phylloxera living on root pieces will provide a source of spread as their food supply is used up.

Slowing the spread of infestation

Experience in other viticultural regions has shown that phylloxera eventually will reach every vineyard in an infested district despite intensive preventive efforts. Nevertheless, preventive practices can delay initial infestations and slow their spread once they do occur (see Chapter 2, "Reducing the risk of phylloxera infestation").

Be aware that phylloxera can live on the roots of vines grafted onto resistant rootstocks. The resistant rootstock actually is tolerant of phylloxera infestations and does not die as a result of phylloxera feeding. Therefore, vines grafted to resistant rootstocks can be a source of initial infestation in your vineyard. Avoid planting infested stock (see Chapter 8, "Buying winegrape plants").

Establish a strict sanitation program to ensure that no equipment (vehicles, tractors, cultivators, mowers), tools, or supplies (picking totes, buckets, stakes) move into or out of the vineyard without first being cleaned of all soil and plant debris. Sanitation practices should be followed for *all* vineyards, including those grafted to resistant rootstocks, because resistant stocks can support phylloxera populations. Educate all vineyard workers about phylloxera and how to prevent or reduce its spread.

Other vineyard management practices can reduce the risk of spreading phylloxera. Schedule all vineyard operations in the infested areas last. Restrict tillage to the period between November and May when phylloxera populations are at their lowest. If you decide to use clean cultivation between rows to reduce competition for water, be aware that tilling during the season is very likely to facilitate the spread of phylloxera. Tilled aisles also increase the risk of rain or erosion moving infested soil downhill, and tillage results in more mud on boots and equipment.

No insecticide effectively controls phylloxera infestations in established plantings. One is being evaluated to slow the rate of spread. Soil treatments hold little promise, however, because of the great depths at which phylloxera occur, and because chemical penetration is poor in heavier soils. The only

long-term solution to the phylloxera problem is the use of resistant rootstocks (see Chapter 6, "Replanting options for establishing phylloxera-resistant vineyards," and Chapter 7, "Phylloxera-resistant rootstocks for grapevines").

Analyzing your options

Several options are possible: pull out the vines after they become unprofitable and don't replant; replant infested blocks when they become unprofitable to manage; or replant the entire vineyard in a scheduled piecemeal replant program.

Your decision to replant an infested vineyard site should come only after you carefully consider the circumstances of your vineyard operation and business.

The deciding factor should be the profitability of a vineyard block. Good recordkeeping is an invaluable aid in making this important replant decision. Review records of production, costs, and revenues for past years. Monitor the rate of spread of phylloxera and decline of vines to help you predict how long your infested block can remain profitable (see Chapter 4, "How to monitor rate of spread of phylloxera in your vineyard").

Consider also the existing features of your vineyard. Are the varieties and clones well suited to your site and the future wine market? Replanting provides an opportunity to change some of the features of your production system such as variety, clone, spacing, and training system in order to improve your production efficiency, fruit quality, or crop marketability. If you decide to replant, use only phylloxera-resistant rootstocks.

Chapter 6

Replanting options for establishing phylloxera-resistant vineyards

S. Price

Grape growers with infested vineyards or growers wishing to avoid infestation have several options available for replanting existing vineyards with phylloxera-resistant plants. This chapter reviews the available options and discusses advantages and possible pitfalls of different replant strategies.

The primary objective of replanting is to establish a new vineyard that is resistant to phylloxera. A second objective is to reduce the costs of the transition. Consider these two objectives together. You should not use a replanting method that will impact the long-term health and viability of the new vineyard. Likewise, you must carefully weigh the economic realities of the transition to protect the financial health of your business.

When to replant

All self-rooted *Vitis vinifera* vineyards in Oregon are at risk from phylloxera, and it is possible that all these vineyards eventually will become infested. However, a vineyard could become infested this year or it might take 30 years. Growers can wait to replant until they know their vineyards are infested, or they can replant to resistant stocks before an infestation is confirmed. Replant strategies may be different in each situation.

Uninfested vineyards

You have the most options if you replant a vineyard before a phylloxera infestation. In this case, you can replant based on a long-term plan of vineyard replacement and rehabilitation. Thus, you can anticipate financial implications of replanting and spread

replanting costs over a longer period. You can base the order of block removal and replacement on block profitability. You also can order planting material well in advance and integrate the replacement process into a larger plan of vineyard rejuvenation and improvement. In short, your decisions are planned rather than dictated by the spread of phylloxera and the pattern of vine decline.

Consider replanting first in vineyard blocks with problems. For example, replanting provides an opportunity to renovate or change trellis systems, change vine and row spacing, change varieties or clones, or add an irrigation system or drainage tile. In addition to conferring phylloxera resistance, rootstocks also can be used to correct problems with excess vigor, water stress, poor fruit set, or vine nutrition.

Replanting profitable blocks before a phylloxera infestation is confirmed is a more difficult decision. Replanting still has advantages, particularly in the long term. A vineyard on resistant rootstocks will provide a supply of grapes that will not be interrupted by phylloxera, and resistant rootstocks substantially add to a vineyard's resale value. You must keep re-establishment time to a minimum in any situation, but that becomes especially critical with profitable production blocks where time without fruit production must be kept as short as possible.

Infested vineyards

Because phylloxera eventually will move throughout the vineyard, prepare a replanting schedule for the entire

vineyard. Replanting schedules will be dictated by the decline of phylloxera-infested vines (see Chapter 4, "How to monitor rate of spread of phylloxera in your vineyard"). You will need to remove or replant

blocks with declining production when they no longer are profitable to manage.

Your first priority should be visibly infested areas. However, avoid spot replacement of visibly infested vines. Distribution of phylloxera in the vineyard is much wider than the area of visibly affected vines, and vines outside a weak spot will continue to decline. Also, the patchwork of different vine ages down a row that results from spot replanting is difficult to manage. Replant infested areas on a row-by-row basis and extend the replanted area well beyond the borders of the visible infestation.

Replant the least profitable blocks next with the added goal of vineyard improvement. Replanting apparently healthy, productive blocks will be your most difficult decision. You must balance the temporary lost revenue against the potential value of an entirely phylloxera-resistant vineyard.

Planting resistant rootstocks in an infested site is not insurance against

Start planning now! The more prepared you are, the more likely that replanting will be an opportunity for improvement rather than a desperate attempt to rescue a dying vineyard.

continued spread of phylloxera in self-rooted areas of the vineyard. Many phylloxera-resistant rootstocks will support phylloxera populations, and these can serve as a reservoir for continued spread (see Chapter 8, "Buying winegrape plants").

Replanting options

Growers replanting vineyard blocks can choose to replant after vine and trellis removal, to replant attempting to reuse existing trellis structures, or to attempt to plant between existing vines (interplant). The most prudent course is a complete renovation of the vineyard; it also is the most expensive, both in costs of renovation and in time with lost production. Interplanting is the other extreme. There are potential cost advantages to interplanting, but it has a much greater risk of failure.

Traditional European viticulture recommends a rest period of 5 to 6 years before replanting a vineyard. This period can be shortened to 3 years if the soil is fumigated. The primary justification for this practice is the possible presence of nematodes, fungi, and phylloxera. Phylloxera can weaken young vines, even those on resistant stocks. It is unlikely that many Oregon growers will wait 5 years to replant, but it is important to recognize potentially serious problems associated with immediate vine replanting.

Evaluate vineyard blocks before making replant decisions. Identify the vineyard's limitations, and determine whether replant strategies offer an opportunity to correct them:

- Is the production system efficient?
- What is the anticipated lifespan of the trellis?
- Could the spacing or trellis system be changed to improve quality or production?
- Should an irrigation system be installed or renovated?
- Are there limiting soil factors such as compaction, nutritional shortages, acidity problems, or poor drainage?

- Are there pathogenic nematodes or fungi present in the soil?

Many of these factors can be corrected most effectively before planting, without existing plants or trellises obstructing access to the entire block.

Vineyard renovation

This is your only choice when the existing vineyard has serious, correctable limitations. Renovation allows deep ripping to loosen hardpans and pull up old vine roots. You can leave blocks fallow or plant cover crops to improve soil health and to reduce phylloxera and nematode populations. Fumigation is an option only in the absence of growing plants. Soil nutritional modification requiring deep incorporation of phosphorous, potassium, or lime is most convenient in the absence of plants or trellis structures. Permanent modifications of new blocks such as changes in trellis systems or vine spacing or installation of drainage tile also require a fresh start.

Replanting with the existing trellis

Replant within an existing row only if the plan and organization of the vineyard is acceptable and the trellis system will last at least 10 more years. Many of the major vineyard modifications discussed above are not possible if the trellis structure is retained. Removing the old vines may be difficult. In some cases, large, old vines cannot be removed without damaging the trellis system, so they must be cut off and killed with herbicides. The old root system remains in place; however, it may serve as a source of root diseases and could increase phylloxera population pressure on the new rootstocks.

Interplanting

The goal of interplanting grafted vines between producing, established vines is to get the new plants into production while the old ones continue to supply revenue. It is possible that a new

grafted vineyard could be established with little or no loss of production. Do not consider interplanting if the existing vineyard has serious limitations that could be corrected by complete vineyard renovation.

Interplanting has many potential problems. The most serious is competition. Your considerable investment in grafted plants may be lost if the new

plants cannot successfully compete with the established planting. Poor take on new plants could result in a nonuniform vineyard made up

of vines of different ages and different varieties, with and without rootstocks. Also, removing the old vines once the interplants are established may be a problem. Removal can generate potential problems due to nematodes, soil fungi, and high phylloxera populations on the older vines.

If you choose to interplant, your first priority must be to establish the new vines. Adjust vineyard management to favor the growth of the new vines. Management practices to consider are:

- Provide irrigation to new plants.
- Remove permanent cover crops that compete with young vines.
- Use plastic mulch around young vines to reduce weed competition and soil water loss.
- Root prune the established plants.
- Summer prune established plants to increase available light for the new plants.

You probably should remove the established vines within 2 years, at the time the new planting is being trained to the fruiting wire.

Inarch grafting

Self-rooted vines can be converted to vines with resistant rootstocks by a grafting technique called inarching. Resistant stocks can be planted next to the trunks of existing vines and grafted onto the trunk. The goal is to completely replace the root system of the

The most prudent course is a complete renovation of the vineyard; it is also the most expensive.

self-rooted plant with the phylloxera-resistant stock. This technique has been tried in California with mixed results. Some growers were able to change the root system of established vines without losing production. However, it is unlikely this technique would work consistently in Oregon.

Field grafting of any type has never been reliable under Oregon's cool growing conditions. Cool, wet weather after grafting generally results in graft failure. Given Oregon's propensity for unpredictable weather, growers are advised not to try this system except in small-scale experiments.

Whatever replant strategy is used, the most flexibility is available when the planning starts early. Start planning now! The more prepared you are, the more likely that replanting will be an opportunity for improvement rather than a desperate attempt to rescue a dying vineyard.

Phylloxera-resistant rootstocks for grapevines

M.C. Candolfi-Vasconcelos

Grafting, which combines two different varieties or species to form a new plant with a blend of characteristics, is a technique known from ancient times both in fruit trees and viticulture. It has been used historically to change variety, enhance vigor, or increase limestone tolerance.

Grafting became a common practice in viticulture after the phylloxera epidemic. Laliman was the first to suggest biological pest control of phylloxera: grafting the susceptible wine varieties to the resistant American species.

The rapid adoption of this practice led to a chaotic period from 1880 to 1930 when nurseries offered a confusing and disorderly assortment of rootstocks. The use of inappropriate rootstocks caused new problems, particularly lime-induced chlorosis.

Extensive research on rootstocks after 1950 revealed that several aspects of scion behavior were dependent on features of the rootstock. These include adaptation to growing conditions, susceptibility to mineral deficiencies or toxicities, tolerance to soilborne pests and diseases, vigor, productivity, and fruit quality. After more than a century of experimentation with rootstocks in Europe and in the New World, there is a considerable amount of information to draw upon.

Still, the choice of a rootstock for a particular location depends on the complex interactions between soil type, depth, and physical and chemical properties, and pests, diseases, water availability, and environmental factors. Thus, on-site evaluation is imperative.

Choosing the appropriate rootstock

Rootstocks susceptible to phylloxera are still being planted, usually because they are easy to propagate, which makes them attractive to the nursery industry and furthers their availability in the market. However, there is at present a vast choice of phylloxera-resistant rootstocks with a wide range of adaptability to different soil and climatic conditions.

The parentage of rootstocks currently offered in nurseries is illustrated in Figure 1.

The first criterion in choosing a rootstock is its resistance to grape phylloxera. Resistance to nematodes also is important in infested soils, but a nematode-resistant rootstock with questionable phylloxera resistance is not a wise choice.

Exceptions to the rule are rootstocks to be grown in very light siliceous or sandy soils, provided that the sum of silt, clay, and humus in the soil does not exceed 5 percent. In these soils, vines do not seem to be affected by phylloxera and can be grown self-rooted (not grafted) or grafted to nematode-resistant rootstocks such as Harmony, Freedom, Ramsey, Dog Ridge, or 1613 C. The clay content should not exceed 3 percent. Grafting to phylloxera-resistant rootstocks

There is at present a vast choice of phylloxera-resistant rootstocks with a wide range of adaptability to different soil and climatic conditions.

becomes imperative if the clay content exceeds 7 percent.

Rootstocks with *Vitis vinifera* parentage should not be used because they are insufficiently resistant to phylloxera. The use of some rootstocks recommended in Europe for limestone

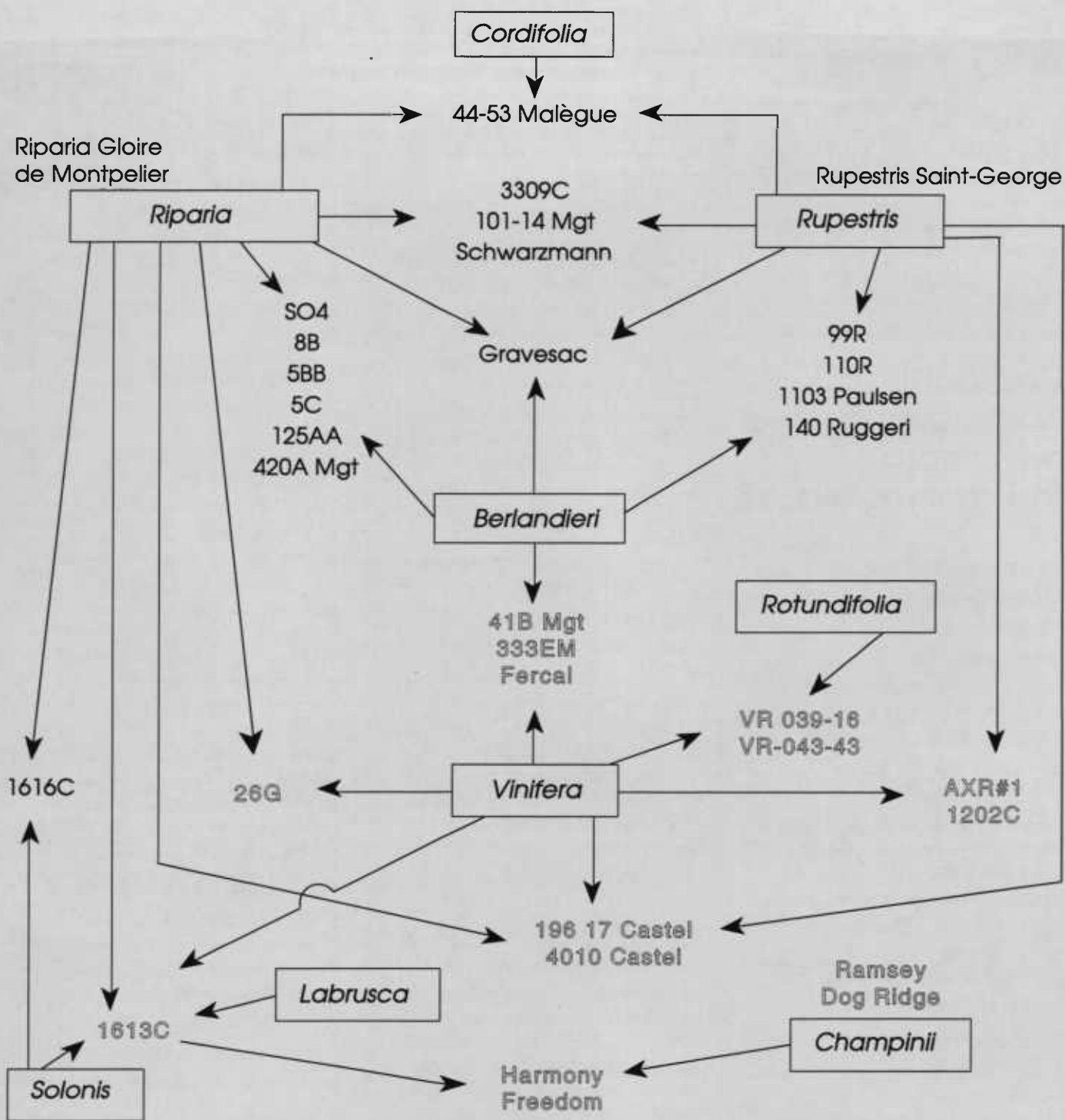
tolerance, such as 41B, 333 EM, and Fercal (crosses of *V. berlandieri* and *V. vinifera*), is not imperative in Oregon because most of our vineyard soils are slightly acid.

Other viticultural attributes of rootstocks, such as drought and lime tolerance, are secondary factors in selecting a stock to suit a particular soil type or vineyard condition.

To obtain the best fruit quality, avoid excessive vine vigor. The best wines of the world are produced on low- to moderate-vigor vineyards. It is very important to adapt the rootstock choice to the soil and climate to optimize vine size. Do not use vigorous rootstocks in fertile soils. However, high-vigor rootstocks can be of great value under very dry conditions, in nonirrigated vineyards. Trellising systems with divided canopies and widely spaced vines require more vigorous rootstocks than single-curtain, closely spaced systems.

Root density (root mass per volume unit of soil) is predominantly a function of rootstock cultivar. Spatial root distribution is a function of the soil environment. Rootstocks that

Figure 1.—Parentage of the commonly grafted rootstocks.



avoid water stress by developing a deep root system should not be used in soils that are shallow or where soil layering prevents deep rooting.

Mineral deficiencies sometimes are aggravated by less favorable scion-rootstock combinations. In soils poor

in magnesium, varieties with high magnesium demand (such as 'Chasselas,' 'Cabernet Sauvignon,' 'Merlot,' 'Cardinal,' 'Gewürtztraminer,' 'Ugni blanc,' 'Sauvignon blanc,' and 'Syrah') should not be grafted onto rootstocks susceptible to magnesium deficiency. Similarly, if the

levels of potassium in the soil are low, varieties with high potassium demand (such as 'Cabernet Sauvignon,' 'Merlot,' 'Aramon,' 'Cinsaut,' 'Syrah,' and 'Müller-Thurgau') should not be grafted to rootstocks prone to potassium deficiency.

A rootstock's resistance to nematodes depends on the nematode species. The information reported here refers to root-knot, dagger, and root-lesion nematodes, which are the most common nematode pests in foreign viticultural regions. In Oregon, studies are showing that the most common species seem to be the ring nematode (*Criconebella* spp.) and the dagger nematode (*Xiphinema* spp.). There is no information available on rootstock cultivar resistance to ring nematode, but we hope to fill this gap in the near future.

Characteristics of commonly grafted phylloxera-resistant rootstocks

Riparia Gloire de Montpellier

Vigor: Low to moderate.

Effect on fruit set: Improves flowering and berry set. Varieties grafted to this rootstock often have declined through a tendency to overbear.

Effect on maturity: Advances maturity.

Soils: Shallow-growing, well branched root system. Suited only to deep, moist, and fertile soils with good drainage. Should not be used in poor, sandy soils. Not appropriate for calcareous soils and dry sites.

Pests and diseases: Very high resistance to phylloxera.

Propagation: Roots and grafts easily. Good graft compatibility with *V. vinifera*.

Other comments: In poor growing conditions, vines grafted on *Riparia* give stems that remain thinner than the scion grafted on it. Therefore, it is not appropriate for low-density plantings with considerable fruit weight per vine. It still is considered one of the best rootstocks for quality winegrape production.

Rupestris Saint George

Vigor: Very vigorous.

Effect on fruit set: Due to extreme vigor, it induces coulure (poor fruit set) and therefore is not suitable for varieties with irregular set.

Effect on maturity: Has a long vegetative cycle and delays the maturity of the scion.

Soils: Needs a deep soil and a penetrable subsoil. Under such conditions, it can resist drought even if the soil is poor. In shallow, dry soil, it will suffer from drought sooner than *Riparia*. On no account should it be planted where there is stagnant water in the subsoil during the growing season.

Pests and diseases: High resistance to phylloxera. Very sensitive to root-knot, sensitive to dagger, and moderately resistant to root-lesion nematodes. Very susceptible to the root-rotting fungi *Dematophora nectarix* Hartig and *Agricus melleus*, and very sensitive to fanleaf degeneration.

Propagation: Roots easily, grafts well, and has excellent affinity with *V. vinifera*.

Other comments: Has a tendency to produce shoots from below the graft. In the nematode-infested, deep, irrigated, sandy soils of the coastal plains of southern France, *Rupestris* St. George is being replaced by SO4, which performs much better under those conditions.

Riparia x Rupestris crosses

Based on the excellent cultural characteristics of these two species, it was expected that the crosses would lead to high quality rootstocks. In fact, following their hybridization, these rootstocks expanded rapidly in every viticultural country and were highly praised in the beginning. They still are regarded as rootstocks for quality winegrape production. In France, however, their use is decreasing in favor of *Berlandieri x Riparia* crosses, which have a superior adaptation spectrum.

3309 Coudrec

Vigor: Low to moderate.

Effect on fruit set: Recommended for varieties with poor set, but the high fruitfulness it induces requires crop removal in young vines.

Effect on maturity: Advances the maturity of the scion.

Soils: Has a deep, well-branched root system. It is a good rootstock for deep, well-drained cool soils that are well supplied with water. Unsuitable for dry and shallow conditions and not appropriate for compacted soils. Has a moderate resistance to lime-induced chlorosis. Does not tolerate saline soils well. Has a tendency to induce potassium deficiency in overcropped young vines on clay soils. Experience from California shows that young vines grafted onto 3309 are very nutrient demanding.

Pests and diseases: High resistance to phylloxera. In France, it is reported to be sensitive to any species of root-knot nematodes and in California is regarded as susceptible to nematodes. However, in Australia, it is considered resistant to dagger and root-lesion nematodes. Experiments in South Africa showed that 3309C is resistant to crown gall but susceptible to phytophthora. It recently has acquired a bad reputation in California for its sensitivity to viruses when grafted to field selections of scion wood.

Propagation: Easy to graft and root.

Other comments: In Burgundy, it is being replaced by SO4. Experience in California and Australia suggests that other rootstocks usually are better.

101-14 Millardet et de Grasset

Vigor: Low to moderate.

Effect on fruit set: Improves fruit set (better than 3309C in Switzerland).

Effect on maturity: Advances maturity (shorter cycle than 3309C).

Soils: Has a fairly shallow, well-branched root system and requires moist, deep soils. A good rootstock for fresh clay soils even if they are poorly drained. Not appropriate for dry and well-drained positions on slopes. Has a

moderate resistance to lime-induced chlorosis. Should not be used in acid soils without first applying lime to improve pH. Resistant to salinity.

Pests and diseases: Has high resistance to phylloxera. Moderately resistant to nematodes. In South Africa, it is reported to be resistant to crown gall and moderately resistant to phytophthora.

Propagation: Easy to graft and root. In South Africa, it shows lack of compatibility with some varieties such as 'Syrah' and 'Chardonnay.'

Other comments: In Switzerland, compared to 3309C it produced slightly higher yields with the same sugar content.

Schwarzmann

Vigor: Moderate (more vigorous than 3309C and 101-14).

Effect on fruit set: Improves the fertility of the scion.

Soils: In Australia, it does best on moist, deep soils and should not be used where summer drought is common. According to Galet (France), this is a good stock for dry, nonchlorotic soils. In New Zealand, it is not recommended for excessively heavy soils.

Pests and diseases: High resistance to phylloxera. Highly resistant to root-knot and dagger nematodes.

Propagation: Easy to graft and root.

Other comments: The advantage of this rootstock compared to Riparia Gloire and the other Riparia x Rupestris hybrids is that it is more tolerant to calcareous soils, and its trunk thickens as rapidly as that of the scion grafted on it. This rootstock of uncertain origin probably is a descendent of the 101 series from Millardet. It is not well documented in the literature.

Berlandieri x Riparia crosses

This group is characterized by good phylloxera resistance, resistance to lime in the soil, and good affinity with *V. vinifera*. These crosses typically

confer low to moderate vigor to the scion, and some of them are drought tolerant. They are suited to cool climate, quality wine-growing areas due to earliness of maturity and moderate vigor. They probably are the group best suited to Oregon conditions.

Selection Oppenheim 4 (SO4)

Vigor: Moderate to vigorous.

Effect on fruit set: The available information 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.

Effect on maturity: Advances the maturity of the scion according to researchers in Germany, South Africa, and New Zealand. However, according to French literature, it delays maturity.

Soils: Has a shallow-growing root system. Tolerates high levels of lime in the soil and performs satisfactorily in acid soils. Well adapted to a wide range of soils but does best in light, well drained soils of low fertility. Suited to humid soils but not recommended for dry conditions. In New Zealand, it is reported to be drought-tolerant. Assimilates magnesium poorly and, when grafted with 'Merlot' or 'Cabernet Sauvignon,' induces inflorescence necrosis.

Pests and diseases: Very high phylloxera resistance and is resistant to root-knot nematodes. In France, it favors the development of botrytis infestation in the fall due to excessive vigor. Varieties with high magnesium demand should not be grafted onto SO4 because they tend to show magnesium deficiency and inflorescence necrosis symptoms. Susceptible to thyllosis.

Propagation: Roots well, but results of bench grafting sometimes are disappointing.

Other comments: Stock develops slowly and shows low vigor in the first years of development. Vine vigor decreases drastically after 15 to 20 years, leading to the need to re-establish the vineyard. In California, 5C was mistaken for SO4 for many years.

Teleki 8B

Vigor: Moderate.

Effect on fruit set: Very fruitful in good soils but not appropriate for high-yielding varieties.

Soils: Shallow-growing root system. Not appropriate for shallow, dry soils. Very resistant to lime-induced chlorosis. More drought-tolerant than 5BB.

Pests and diseases: Has high phylloxera resistance and is resistant to root-knot nematodes.

Propagation: Roots poorly but grafts well.

Other comments: This stock originally was a mixture of five plants and was further selected in Germany (Durlach 50, 51, 52), Italy (Ferrari, Cosmo 2, and Cosmo 10), and Romania (Dragasani 37, 57).

Kober 5BB

Vigor: Vigorous.

Effect on fruit set: Can cause imperfect set in vigorous varieties and fertile soils.

Effect on maturity: Has a relatively short season. In vigorous, valley floor sites, the excess of vigor can affect fruit set and delay maturity.

Soils: Shallow-growing root system. Tolerates high levels of lime in the soil. One of the best stocks for humid, compact, calcareous soils. Less appropriate for sites with prolonged drought. No salt tolerance. Not suitable for high-yielding varieties due to poor potassium uptake.

Pests and diseases: Has very good resistance to phylloxera and moderate resistance to root-knot and dagger nematodes. In California, it is reported to be sensitive to phytophthora and, thus, not recommended for sites likely to have standing water. Susceptible to thyllosis.

Propagation: Roots and grafts well. Some incompatibility with table grape varieties was reported in Italy and with wine varieties ('Cabernet franc,' 'Colombard,' 'Servant,' and 'Abouriou') in France.

Other comments: Not suited for regions affected by severe winter frosts because its roots do not tolerate temperatures below -8°C (18°F) at 30 centimeters depth (12 inches).

Teleki 5C

Vigor: Moderate (between 5BB and SO4).

Effect on fruit set: Well suited for varieties with poor set.

Effect on maturity: Advances maturity. The earliest maturing rootstock of this group.

Soils: Suitable to well-drained, fertile soils. A good choice for heavy soils (clays and clay loams). Has moderate drought resistance and high tolerance to calcareous soils.

Pests and diseases: Very good resistance to phylloxera and good resistance to root-knot and dagger nematodes.

Propagation: Roots and grafts well.

Other comments: Selected in Austria from Teleki 5A. In California, it was erroneously sold as SO4. This rootstock has many of the attributes of 5BB except that it tends to advance ripening. It therefore has special value for very cool climates.

Kober 125AA

Vigor: Very vigorous.

Effect on fruit set: Not appropriate for varieties with irregular set.

Soils: Moderately resistant to lime-induced chlorosis. Greater drought tolerance than 5BB. In Germany, it is recommended for a very wide range of soils, particularly heavy, compact soils with poor aeration and drainage. Not appropriate for shallow soils. In New Zealand, however, it is recommended for poor, stony soils.

Pests and diseases: High phylloxera resistance.

Propagation: Roots well but initially develops slowly.

Other comments: In most aspects, this rootstock is similar to 5BB, although it is more vigorous in growth and is recommended for special conditions only. It gives good results with 'White

Riesling,' 'Müller-Thurgau,' 'Sylvaner,' 'Chasselas,' and the 'Pinot' family. It is best suited to high-yielding varieties such as 'Müller-Thurgau.'

420A Millardet et de Grasset

Vigor: Low to moderate.

Effect on fruit set: Improves scion fertility.

Effect on maturity: Has a long vegetative cycle.

Soils: Root system is fairly shallow-growing and well branched. Well-suited to poorer, heavy-texture soils. A good stock for dry hillside sites, according to Italian and Australian sources, but susceptible to drought according to French and South African sources. Does not withstand waterlogging. Has good resistance to lime-induced chlorosis, but is prone to potassium deficiency.

Pests and diseases: High phylloxera resistance. Moderate resistance to root-knot nematodes but susceptible to dagger and root-lesion nematodes. Susceptible to phytophthora.

Propagation: Does not root or graft easily. Has poor affinity with 'Sangiovese' in Italy.

Other comments: The oldest commercialized Berlandieri x Riparia hybrid and is used mainly for early-ripening table grapes and high-quality winegrapes. Grows very slowly and has a tendency to overcrop in early years of vine development.

Berlandieri x Rupestris crosses

The rootstocks belonging to this group are vigorous, often very resistant to drought, and are the best adapted to warm regions. They have high phylloxera resistance and tolerate calcareous soils. The vegetative cycle usually is longer than the Berlandieri x Riparia and Riparia x Rupestris crosses and, therefore, they are less adequate for cool-climate regions. However, their adaptability to poor growing conditions, infertile soils, and drought are among the characteristics that make this group worth trying in Oregon.

99 Richter

Vigor: Very vigorous.

Effect on fruit set: Has a much shorter vegetative cycle than Rupestris St. George, which means that it could be grown under cool conditions.

Effect on maturity: Delays scion maturity.

Soils: Root system very strongly developed and very deep-growing. Well-suited to a wide range of soils, but wet, poorly drained situations should be avoided. Drought-tolerant and performs well in acid soils. Does not tolerate salt but tolerates high levels of lime in the soil. Assimilates magnesium poorly.

Pests and diseases: High resistance to phylloxera and root-knot nematodes and moderate resistance to dagger and root-lesion nematodes.

Propagation: According to South African experience, it roots and grafts extremely well, but the French report less successful results with bench grafting.

Other comments: This was the outstanding rootstock in a long-term rootstock trial in Victoria, Australia. In France, under dry conditions, its performance usually is inferior to 110R. In South Africa, it is considered the best rootstock for deep, fertile soils under irrigation.

110 Richter

Vigor: Moderate to vigorous.

Effect on fruit set: Not appropriate for varieties with irregular set.

Effect on maturity: Very long vegetative cycle delays maturity.

Soils: Root system not as deep-growing as that of 99R or Rupestris St. George. Well-suited to all kinds of soils, including acid soils. An excellent rootstock in warm grape-growing areas with an arid climate. Resistance to drought is superior to 99R, and it does well on badly drained, shallow clays. A good rootstock for slopes or dry-farmed sites. Assimilates magnesium and potassium poorly but tolerates lime in the soil.

Pests and diseases: Highly resistant to phylloxera. Moderate resistance to root-knot nematodes.

Propagation: Roots and grafts well.

Other comments: This is one of the most important rootstocks in Portugal, Spain, Greece, North Africa, and Israel and ranks third in plantings in France. Initial vine growth is slow because it first develops the root system.

1103 Paulsen

Vigor: Moderate to vigorous.

Effect on maturity: Has a long vegetative cycle, thus delaying maturity of the scion.

Soils: Root system is deep-growing and strongly developed, resembling that of *Rupestris* St. George. Reported to be more drought tolerant than 110R and 140Ru in Sicily and Algeria. In calcareous soils in France, it performs better than 99R but not as well as 110R, 161-49C, SO4, and 420A. Does well in acid soils. Moderately tolerant of salt but assimilates potassium poorly.

Pests and diseases: Has high resistance to phylloxera, good resistance to root-knot nematodes, and moderate resistance to dagger nematodes.

Propagation: Roots and grafts well and has good affinity with *V. vinifera*.

Other comments: This rootstock was bred and selected in Sicily and is used in Italy, southern France, and North Africa.

140 Ruggeri

Vigor: Very vigorous.

Effect on fruit set: In fertile soils, causes poor fruit set due to excessive vigor.

Effect on maturity: A very long vegetative season delays maturity.

Soils: Root system is very deep-growing and well branched, resembling that of *Rupestris* St. George. Because of extreme vigor, not recommended as a rootstock for deep, fertile soils that are well supplied with water. Performs well in shallow, dry, calcareous soils and is very drought tolerant, well-adapted to acid soils, and resistant

to salinity. In the group *Berlandieri* x *Rupestris*, it is the most resistant to lime in the soil. Assimilates potassium poorly.

Pests and diseases: Highly resistant to phylloxera. Moderate resistance to root-knot nematodes.

Propagation: Grafts well but is not easy to root.

Other comments: This is a Sicilian rootstock, very popular in Italy and North Africa. It is considered the best rootstock for arid, calcareous soils.

Riparia x *Solonis crosses*

1616 Coudrec

Vigor: Moderate.

Effect on fruit set: Improves scion fertility.

Effect on maturity: Advances the maturity of the scion.

Soils: Root system shallow-growing and well branched. Sensitive to drought and best adapted to fertile, humid, badly drained soils provided they do not contain much lime. Grows poorly in infertile and light sandy soils. High tolerance to salt and, in France, is used mostly on saline soils along the Mediterranean coast.

Pests and diseases: Good resistance to phylloxera and high resistance to root-knot nematodes.

Propagation: Roots well, but the results of bench grafting are poor.

Other comments: The main advantages of this rootstock are the nematode and salt resistance.

Complex crosses

Riparia x *Cordifolia* x *Rupestris*

44-53 Malègue

Vigor: Moderate.

Effect on fruit set: Improves fruit set of the scion.

Effect on maturity: Advances maturity.

Soils: Root system is deep-growing and very strongly developed. Performs well under drought conditions.

Moderate resistance to lime-induced chlorosis but often suffers from magnesium deficiency. Used in the acid soils of the eastern Pyrenees, and may be a good stock for dry regions as long as the soil is low in lime.

Pests and diseases: Very high resistance to phylloxera. Resistant to nematodes and has been reported to be resistant to fanleaf virus.

Propagation: Roots and grafts extremely well.

Other comments: Qualities are similar to the stock 3309C.

Riparia x *Berlandieri* x *Rupestris*

Gravesac

Vigor: Moderate.

Soils: Suited for well-drained soils of low fertility. Tolerates acid soils and is resistant to lime-induced chlorosis.

Pests and diseases: High phylloxera resistance.

Propagation: Roots and grafts well and has good affinity with the varieties tested so far.

Other comments: This is a new rootstock, bred in Bordeaux specifically for tolerance to acid soils (cross of 161-49C and 3309C). It still is being tested. In Bordeaux, it performs like SO4. It is not available in the United States, but it would be interesting to test in Oregon.

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Chapter 8

Buying winegrape plants

B. Strik and P. Stonerod

Selecting good plant material is a critical step in establishing a profitable vineyard. Considering vineyard establishment costs and potential longevity, it is important to start with clean plant material. Choosing a good nursery source is an important step in procuring good quality, true-to-type plants. When you've made decisions on what cultivars or clones to plant, you still need to choose plant type (green or dormant, self-rooted or grafted) and plant disease status (certified, or hot-water-dipped for pest control). All these things must be considered when ordering your plants.

Choosing a good nursery source is an important step in procuring good quality, true-to-type plants.

Plant type

Nurseries sell dormant field-grown and greenhouse (green) potted plants. Green plants need to be hardened off properly before planting and may need more careful irrigation after planting. Check with nurseries for availability and recommendations.

Grade

Dormant, field-grown plants are available in two grades based mainly on plant size. Check with nurseries for availability and costs of grades for the cultivars or clones you're interested in.

Self-rooted or grafted?

Although self-rooted (nongrafted) plants are about one-sixth the cost of grafted vines, the Oregon State University Extension Service does not recommend planting self-rooted vineyards in Oregon due to the presence of phylloxera. Self-rooted

European winegrapes are not resistant to grape phylloxera and will die after they become infested. Vines grafted onto a resistant rootstock are the best insurance and the only control measure against phylloxera. There are many types of grafted rootstocks from which to choose. Select a resistant stock that best suits your site and desired viticultural traits (see Chapter 7, "Phylloxera-resistant rootstocks for grapevines").

The most popular rootstock–scion combinations are in great demand. Order your plants well in advance of your desired planting date.

Plant disease status

Grape quarantine

The Oregon Department of Agriculture has an established plant quarantine against fanleaf and leaf roll viruses and grape phylloxera. If you wish to purchase plants from nurseries in California or other states, you must follow these regulations. It is against quarantine regulations to import grape plant material that is **not** certified to be free of fanleaf and leaf roll viruses and phylloxera. Also, the only rooted grape plants that may be imported are those that have been grown in soilless, sterile media. For more information, contact the Oregon Department of Agriculture.

Treatment of nursery plants

Plants purchased from Oregon grapevine nurseries commonly are field-grown. Nursery inspectors check plants

for presence of phylloxera or symptoms of infestation in the winter when plants are dug. However, this and other certification or inspection methods for phylloxera are not foolproof because it is very difficult to find this insect pest. Certified grapevine nurseries in Oregon also are inspected once during the growing season for presence of leaf symptoms of viral infestation. Approximately every 5 years, nurseries are sampled during the growing season for the plant parasitic nematodes that vector the fanleaf and leaf roll viruses.

As added insurance against phylloxera infestation, some nurseries treat their plants in a hot water dip or with insecticide to kill any phylloxera that may be present. This may increase the cost of plants.

For an effective hot water dip, plants must be dipped for 5 minutes at 110°F (to warm the roots) and 5 minutes at 125°F to kill any phylloxera life stages present. We have shown that this treatment eradicates phylloxera without harming self-rooted or grafted plants **that are dormant when dipped**.

As an alternative to hot water dipping, the insecticide Malathion 5EC is registered for use as a nursery plant treatment for insect control. Nurseries or growers using this product should check the label carefully prior to use.

Keep in mind that phylloxera can live on the roots of resistant rootstocks. The resistant rootstock does not die as a result of phylloxera feeding but can serve as a source of phylloxera that infest nearby vineyards. This is an important fact to keep in mind, especially if you're planting near an established European, self-rooted vineyard block.

Chapter 9

Tips for producing phylloxera-resistant grafted vines

S. Price

Planting winegrape plants grafted to phylloxera-resistant rootstocks is the only sure way to avoid phylloxera damage to a vineyard. Grafted plants are expensive, however (five or six times the cost of self-rooted cuttings).

You can reduce the cost of replanting if you produce your own grafted plants. Bench grafting is a relatively simple process, but observing several key points can greatly affect your success.

Some Oregon growers use the following system with good results. It is a modification of a commercial system used in several New Zealand nurseries and appears to work well there on all the standard rootstocks. Unlike traditional methods, it does not require an 80°F callusing room or a greenhouse, making it an appealing system for small-scale grafting operations.

Timing of the whole operation depends on the planting date in the nursery. To plant cuttings in warm soil in mid- to late May, graft in early to mid-April.

First, cut rootstock wood to length (12 to 16 inches) and disbud it. You can disbud rootstock wood with a pruner at the time of collection or later using a wire brush on a bench grinder.

All wood for grafting must be stored under cool, moist conditions prior to use to avoid desiccation. Carefully select single-node scions for grafting to match the size of the rootstock.

Grafts can be made by hand, using a whip and tongue graft for example, but they are easiest when done with a grafting machine that makes either an omega, slot, or “V” cut. Secure the

graft union with a 1-inch wrap of plastic electrician’s tape. Then dip the graft union and the bud in a mix of equal parts beeswax, paraffin, and linseed oil and then in cold water. Make sure the wax is not too hot—keep it just above the melting point.

Callus the grafted cuttings in a waterproof container at least 18 inches high. New Zealanders use a range of containers, from waxed lettuce boxes with their sides taped up to 4-square-foot plastic picking bins.

Fill the container with 9 inches of moist perlite and place the grafted cuttings in the container with the graft union up. The graft union should be several inches above the perlite. Seal the whole container with transparent plastic to keep the air in the container at 100 percent humidity.

Keep the temperature inside the box at 80°F. Be sure to monitor the temperature both in the air, under the plastic, and in the perlite.

Lights should be suspended over the containers. The light source is not important—banks of fluorescent lights, quartz work lights, and incandescent bulbs all work well. Usually the lights supply all the heat necessary. Adjust the temperature in the container by raising or lowering the lights.

Some rootstocks may require bottom heat to improve rooting, but this

probably is not necessary with most of the common rootstocks being considered in Oregon.

Unlike traditional methods, the method described here does not require an 80°F callusing room or a greenhouse, making it an appealing system for small-scale grafting operations.

After 3 to 5 weeks, when new shoots on the scion are about 1 inch long, remove the grafted cuttings from the boxes. If there are longer shoots, trim them to two nodes and remove the larger leaves.

Again dip the top of the cutting either

in wax (this time, a mix of equal parts beeswax and linseed oil) or a plastic antitranspirant. If you use wax, keep the temperature cooler than the first dip, and dip the grafted cutting in cold water after the wax dip.

After callusing, you can plant the grafted cuttings directly in the nursery. Two weeks before planting, cover well-worked soil with 3-foot-wide black plastic strips to warm the soil. Just prior to planting, run a spiked wheel or some other device over the plastic to mark the spacing and cut holes in the plastic. Space cuttings 4 to 6 inches apart, with two rows of cuttings on each plastic sheet. Dig plants the following dormant season.

Typical success rates in New Zealand average around 55 percent. Some Oregon growers have had 90 percent success using this system. At Oregon State University, we have had success rates of 40 to 70 percent, depending on the rootstock. The one noticeable exception was 1616 Coudrec, on which we had no take. The plant quality after

growth in the nursery generally is very good: root systems are large, and top growth is adequate.

The quality of nursery stock you produce will be closely tied to your nursery practices. Generally, the best nursery ground is not the best ground for vineyards. Nurseries should be planted on rich, fertile soil that is easily dug in the winter. A sandy loam is considered ideal. Make sure the

plants are well watered and fertilized during the growing season.

This method is a little different from the standard method of producing bench-grafted plants in the United States, which involves callusing in the dark, hardening off callused plants in a greenhouse, then field planting. Systems similar to the one described here are used on a large scale in France, but the callusing step is done

in a greenhouse instead of a small container.

If you are interested in trying your own grafting, start on a modest scale to get experience with how the system works and what sort of success you have. Most failures are the result of using poor wood, so make sure you can secure a good source of quality plant material and can store it properly until April.



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