Rootstocks

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1. Definition:
	1. A plant onto which another variety is grafted
2. Reasons to Graft onto Rootstock
	1. Resistance to Pests
		1. Phylloxera
			1. American rootstock forms hard, corky layers beneath feeding wound of Phylloxera, making it harder for them to feed and harder for microbes to enter
		2. Nematodes
			1. Roundworms found in soils (see Vineyard Pests)
	2. Tolerance to Lime
		1. Limestone-rich soils may cause chlorosis in vines, a condition where the high active calcium carbonate content in the soil locks up the iron needed to provide chlorophyll for photosynthesis, causing yellowing/whitening of leaves.
		2. Rootstocks with high V. berlandieri content (SO4, 41B, 333EM, Fercal) will help
	3. Tolerance to Acidity
		1. Excess acidity: can lead to aluminum toxicity
	4. Tolerance to Salinity
		1. Can disrupt water uptake and vine nutrition
		2. Rootstocks based on V. berlandieri, champini, and vinifera best
	5. Tolerance to Drought Stress
		1. Berlandieri-rupestris crosses best to help/ V. Riparia are worst
		2. Shallow-rooting rootstocks (41B, 101-14 Millardet et de Grasset useful in irrigated vineyards)
	6. Tolerance to Soil Compaction
		1. Shallow rooting rootstocks vs deep-rooting rootstocks
	7. Control of Vine Vigor
		1. Rupestris-based rootstocks have high level of vigor (Rupestris St. George, 99R, 100R), riparia have lower level (ex: Riparia Gloire de Montpellier (RGM), 420A, 41B, 161-49, 101-14)
		2. Can moderate effects of fertility in soils
			1. Weak vigor rootstocks usually used in cooler climates, as they encourage earlier ripening and can help control yields
3. Grafting
	1. About
		1. Requirement for grafting and budding: viable cambium contact. The cambium is a single layer of cells located just below the bark. This area leads to the formation of the graft union of the scion and rootstock. Increased cambial contact (the more area that touches) between scion and rootstock increases the chances of success.
		2. Grafting takes advantage of the wound healing response in plants
			1. When an incision has been made the response is the growth of de-differentiated cells (cells that have reverted to an unspecialized state), thus respond by producing callus
			2. Callus provides the tissue through which vascular continuity is restored, and those vascular signals influence the undifferentiated callus cells to become cambial cells.
	2. Bench Grafting
		1. Definition:
			1. A method of grafting grape vines in which the fruitwood cutting is notched at the lower end. The rootstock cutting is also notched, but at the upper end and, most importantly, with a notch design which will allow the fruitwood piece to fit into the rootstock piece like two pieces of a jigsaw puzzle. After the two are pressed together in a way which causes the cambium layers to remain in tight contact, the couplet is stored on its side in a warm, moist condition for several weeks until a callous forms around the union, sealing it. Each of these calloused benchgrafts is then "planted" into a milk carton sized container filled with a porous soil substitute. The cartons are held in a warm greenhouse for a few weeks until green growth appears at the upper (fruit variety) end and roots appear in the soil at the rootstock end. Presto, you now have a "rooted benchgraft" ready to be carefully nurtured into a new grapevine, with a Phylloxera-resistant root at the bottom and the fruiting variety you desire on top
	3. Cleft Graft
	4. Bark Graft
	5. Whip Graft
	6. Budded Graft
	7. Top Grafting aka Field Grafting
		1. Definition:
			1. Renewing a grafting operation on a plant which has already been grafted, either bench-grafted prior to planting, or grafted in the field. Top-grafting generally aims at modifying the grape variety of an established and productive vine.
		2. Most Common Methods
			1. Chip Grafting
				1. Carried out up to 10 weeks after budburst
				2. Technique consists of inserting a single bud into a notch (on the stock) of exactly the same size and shape. The first cut, at the base of the notch, is made at a 25° angle to the vertical. The blade of the grafting knife should penetrate about 1 cm. The second cut should start 2 to 3 cm above the first, at an angle reduced by half, in order to connect with the first cut. It then involves removing several thin slices of wood (chips) successively. The scion is then wedged in the bottom of the notch by light pressure so that both cambium layers are in contact and ensure an optimum fit. Both sides of the scion and the trunk should line up.
				3. 
			2. T-Grafting
				1. Very successful when done correctly
				2. Carried out at flowering when sap rises (short window of time)
				3. Using a grafting knife, a T-shaped slit is made in the vine trunk. Then, using the tip of the knife, the slit is carefully opened (the bark flaps must not be torn) and the scion is slid in and down so that cambial contact between the scion and the rootstock is optimum.
				4. 
4. Disadvantages
	1. Costs more: 4-5 times cost of planting ungrafted vines
	2. Some rootstocks were thought to be viable and gained popularity, but then were actually susceptible to disease or pests (AXR1)
	3. Wine Taste: Better or Worse on Grafted Vines?
		1. No evidence, but yields may be to blame
			1. Bordeaux yields pre-Phylloxera: 10-15 hl/ha
			2. Bordeaux yields post-Phylloxera (after vineyards re-planted with clones, trellised): 60-75 hl/ha
5. Types of Rootstocks
	1. Types by Use - Hybrids
		1. Phylloxera resistance
			1. Riparia Gloire de Montpellier (*riparia*)
			2. Rupestris St George (rupestris)
			3. 101–14 Mgt (*riparia & rupestris*)
			4. SO 4 (*berlandieri & riparia*)
			5. 5 BB(berlandieri & riparia)
			6. 41 B (*vinifera & berlandieri*)
			7. 333 EM (*vinifera & berlandieri*)
			8. Fercal (Colombar 2 (*berlandieri & vinifera*) & 31 Richter (*berlandieri & longii*).
			9. Harmony (1613 C *(salonis & Othello)* & Dogridge)
			10. Schwarzmann (Riparia & rupestris)
			11. 99 Richter (*berlandieri & rupestris*)
			12. Disadvantages
				1. Hybrids with *V. Vinifera* tend to not have enough resistance against phylloxera and should be avoided:

*V. vinifera* & *V. rupestris* (including AXR1, and Couderc rootstocks 1202 and 93–5)

*V. vinifera* & *V. riparia*

* + 1. Nematode resistance
			1. Ramsey (*champini*)
			2. Dog Ridge (*champini*)
			3. 1616 C (*long & riparia*)
			4. Harmony (1613 C (salonis & Othello) & Dogridge)
			5. SO 4 (*berlandieri & riparia*)
			6. Schwarzmann (*Riparia & rupestris*)
			7. Muscadines
		2. Lime Tolerance
			1. 41 B (*vinifera & berlandieri*)
			2. 333 EM (*vinifera & berlandieri*)
			3. SO 4 (*berlandieri & riparia*)
			4. Fercal (Colombar 2 (*berlandieri & vinifera*) & 31 Richter (*berlandieri & longii*).
		3. Drought Tolerance
			1. 110 R (*berlandieri & rupestris*)
			2. 140 Ru (*berlandieri & rupestris*)
			3. 1103 P (*berlandieri & rupestris*)
			4. 99 R (*berlandieri & rupestris)*
			5. 101–14 Mgt (*riparia & rupestris*) - shallow roots, perfect for irrigated vineyards
			6. 41 B (*vinifera & berlandieri*) - shallow roots, perfect for irrigated vineyards
			7. Fercal (Colombar 2 (berlandieri & vinifera) & 31 Richter (berlandieri & longii)
		4. Vigor
			1. Rupestris St George (*rupestris*)
			2. Harmony(1613 (solons & Othello) & Dogridge)
			3. Dogridge (*hampini*)
			4. Freedom (1613 *(solons & Othello)* & Dogridge)
			5. Ramsey (*champini*)
			6. 99 R (*berlandieri & rupestris*)
			7. 110 R (*berlandieri & rupestris*)
			8. 5 BB Kober (berlandieri & riparia)
		5. Lower Vigor
			1. Riparia Gloire de Montpelier (RGM) (*riparia*)
			2. 420A (*berlandieri & riparia*)
			3. 41B (*vinifera & berlandieri*)
			4. 161-49 (*berlandieri & riparia*)
			5. 101-14 Mgt (*riparia & rupestris*)
			6. *Disadvantages*
				1. vigorous vines will produce an over abundant canopy that may result in over shading of the fruit which will in turn affect ripening.

high levels of potassium and pH

* 1. Hybrid Rootstocks: About
		1. Riparia Gloire de Montpellier (riparia)
			1. Origin - France, 1880
			2. Advantages
				1. Excellent phylloxera resistance
				2. low vigor, low yields
				3. Early ripening
		2. Rupestris St George (rupestris)
			1. Origin - France, 1879
			2. Nicknames - Rupestris du Lot, Rupestris monticola
			3. Disadvantages
				1. Extreme vigor
				2. Over cropping, and poor crop set
				3. Not used in high quality vineyards
				4. Long growing season
			4. Advantages
				1. Excellent phylloxera resistance
		3. Harmony (1613 C (salonis & Othello) & Dogridge)
			1. Origin - Fresno, California 1966
			2. Advantages
				1. Good root knot and dagger nematode resistance
				2. Good phylloxera resistance
		4. Dog Ridge (champini)
			1. Origin - seed directly from V. champini
			2. Disadvantages
				1. Moderately resistant to phylloxera
				2. May need to be pruned often
				3. Avoided for high quality vineyards
			3. Advantages
				1. Can be used in light-textured soils with high nematode content
				2. Extremely vigorous and should not be used in fertile soils
		5. Schwarzmann (Riparia & rupestris)
			1. Origin: Relatively unknown (seedling selection?)
				1. Not widely used
			2. Disadvantages
				1. Moderate vigor
				2. Not drought tolerant - requires moist soils
			3. Advantages
				1. High resistance to phylloxera
				2. High resistance to nematodes
		6. SO4 (berlandieri & riparia) AKA Selection Oppenheim de Teleki No. 4
			1. Origin - Viticulture School at Oppenheim, Germany
			2. Advantages
				1. Excellent phylloxera resistance
				2. Favor fruit set and slightly advances maturity
				3. Moderate vigor
				4. Good nematode resistance
		7. 5 BB Kober (berlandieri & riparia)
			1. Origin - seedling started in Hungary with Sigmund Teleki
				1. 1904 in France, Franz Kober select 5 BB hybrids
				2. Used widely in Germany and Switzerland
			2. Disadvantages
				1. In certain conditions can have excessive vigor
			3. Advantages
				1. Can be grown in humid and clay soils
		8. 5 C Teleki (berlandieri & riparia)
			1. Origin - 1896 by Alexandre Teleki and Heinrich Birk
				1. Similar to SO4
				2. Mostly used in Germany
		9. 99 Richter (berlandieri & rupestris)
			1. Origin - Franz Richter, 1902
			2. Disadvantages
				1. Vigorous and should not be used in cool regions due to delayed ripening
			3. Advantages
				1. High phylloxera resistance
				2. Moderate nematode resistance
		10. 101-14 Millardet et de Grasset (Mgt) (riparia & rupestris)
			1. Origin - Alexis Millardet and Charles de Grasset
			2. Disadvantages
				1. Moderate nematode resistance
				2. Can only tolerate low lime content
				3. Produces shallow root system
			3. Advantages
				1. Low vigor
				2. Early maturing
				3. Used in higher quality vineyards
				4. High phylloxera resistance
		11. 110 R (berlandieri & rupestris) AKA 110 Richter
			1. Origin - Franz Richter 1902
			2. Disadvantages
				1. High vigour
				2. Delayed maturity - avoid fertile soils
				3. Low nematode resistance
				4. Poor rooting in nursery
			3. Advantages
				1. High phylloxera resistance
				2. Drought tolerant - widely used in Mediterranean climates
				3. Moderately lime tolerant
		12. 140 Ruggeri (berlandieri & rupestris)
			1. Disadvantages
				1. Vigorous rootstock: not suited for fertile, moist soils
			2. Advantages
				1. Suited to dry soils high in lime
				2. Suited for Mediterranean climates
		13. 161-49 Couderc (riparia & berlandieri)
			1. Origin - 1888 George Couderc
			2. Disadvantages
				1. Susceptible to nematodes
			3. Advantages
				1. High resistance to phylloxera
		14. 420 A Millardet et de Grasset (berlandieri & riparia)
			1. Origin - 1887 by Alexis Millardet and Charles de Grasset
			2. Disadvantages
				1. Low nematode resistance
			3. Advantages
				1. Low vigor, hastens to maturity
				2. Great for chalky soils
				3. High phylloxera resistance
		15. 1103 Paulsen (berlandieri & rupestris)
			1. Origin - 1896 by Federico Paulsen, director of American vine nursery in Sicily
			2. Disadvantages
				1. Moderate nematode resistance
				2. Vigor moderate to high
			3. Advantages
				1. Drought tolerant
				2. High phylloxera resistance
				3. Easy to graft and root
				4. Intermediate lime tolerance
		16. 1616 Couderc (longii & riparia)
			1. Origin - 1882
			2. Advantages -
				1. Low vigor
				2. High nematode resistance
				3. High phylloxera resistance
				4. Suited for humid soils
				5. Advances maturity
		17. 3309 Couderc (riparia & rupestris)
			1. Origin: 1881 by George Couderc
				1. Planted 18 seeds in a row of his nursery where he added lime
				2. 5 showed no sign of chlorosis and one, 3309 C was most successful
			2. Advantages
				1. High phylloxera resistance
				2. Medium lime tolerance - better suited to humid and drought-prone soils
				3. Rooting and grafting is easy
		18. 1613 Couderc (Solonia (riparia, rupestris & candicans) & Othello (labrusca, riparia & vinifera)
			1. Origin - 1881 by George Couderc
			2. Disadvantages
				1. Low to moderate phylloxera resistance
			3. Advantages
				1. High nematode resistance
				2. Suited for fertile, sandy, loam soils
				3. Used in California
		19. Fercal (Colombar 2 (berlandieri & vinifera) & 31 Richter (berlandieri & longii).
			1. Origin - INRA Bordeaux, 1959
			2. Advantages
				1. Resistant to phylloxera

grafts easily

chlorosis tolerant

drought tolerant

* + 1. 41B (vinifera (Chasselas) & berlandieri)
			1. Origin - obtained by Alexis Millardet and Charles Grasset in 18882 at Bordeaux
				1. Used in Cognac and Champagne
			2. Disadvantages
				1. Phylloxera and nematode resistant but not absolute
			3. Advantages
				1. High lime tolerance
		2. 333 EM (École de Montpellier) (vinifera (Cab Sauv) & berlandieri)
			1. Origin - 1883 by Gustave Foëx of Montpellier
			2. Advantages
				1. Sufficient phylloxera resistance
				2. Lime tolerant
				3. Drought tolerant
		3. AXR1 (vinifera & rupestris) AKA
			1. Origin - Made by Ganzin in 1879, ARG1 in France, Australia and New Zealand; Ganzin1
			2. Disadvantages
				1. Not sufficiently tolerant to phylloxera (i.e. 1980 California phylloxera outbreak)
			3. Advantages
				1. High vigor and yield
				2. Easy to graft

<https://www.sunridgenurseries.com/index.php/clonal-selections/rootstock-chart>

http://www.wine-grape-growing.com/wine\_grape\_growing/wine\_grape\_rootstocks/grapevine\_rootstock\_selections.htm