History of rootstocks in South Africa (Part 3)

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This is the third article on the history of rootstocks in South Africa. Its focus is on the selection criteria for finding the most suitable rootstock for a specific site. Considerations other than the rootstock characteristics play an important role in the final decision.

Selection criteria for rootstocks

Phylloxera resistance was the first and foremost priority for European breeders, but other equally important characteristics were ease of propagation, which included rooting ability, and grafting compatibility with Vitis vinifera species. Soil adaptability in terms of resistance to lime induced chlorosis was another important parameter since most of Europe and the Mediterranean have soils of lime based origin. Drought tolerance was next in line especially for southern France, southern Italy, the Mediterranean Islands and the north African coast. These were the main selection criteria used by breeders for reconstruction of the European vineyards. More were to follow.

Most rootstock breeding in Europe was done between 1875 and 1910 (mainly in France and Italy). This period created phylloxera resistant, lime and drought tolerant rootstocks that were exported to the New and Old World grape growing countries with phylloxera outbreaks. Nematode resistance became important in the USA for the inland grape growing areas in the San Joaquin Valley in California where the dagger nematode, Xiphinema index, transmits fan leaf virus with disastrous consequences for grape production. Since the 1940s rootstock breeding in California has been focused on developing mostly nematode and fan leaf resistant rootstocks. South African rootstock breeding and selection officially started in 1949 and in Australia in the mid 1960s, while a new rootstock breeding programme commenced in Germany in 1990. The search for rootstocks that fit the criteria for adaptability for local conditions continues.

Determining the most suitable rootstock for a given vineyard site is a complicated decision that requires good technical knowledge of rootstock characteristics. These include:

• Phylloxera resistance.
• Drought tolerance.
• Resistance to different nematode species.
• Resistance to subsoil wetness (“wet feet”).
• Resistance to soil borne fungi like Phytophthora cinnamomi.
• Resistance to lime induced chlorosis (high soil pH associated with free lime in the soil).
• Resistance to salinity.

These alone, however, cannot be used in exclusion of other equally important (sometimes more important) considerations. These include:

• Soil adaptability.
• Availability of irrigation water.
• Choice of scion cultivar.
• Induced vigour in scion cultivar.
• Yield expectation (tons/ha).
• Wine quality parameters.
• Climatic indicators (summer temperatures and relative humidity).

Typical symptom of lime induced chlorosis on Autumn Royal.
The above criteria must be used in combination with experience of local conditions. There is no substitute for experience in finding the most suitable rootstock.

Soil adaptability

Physiological and anatomical differences between rootstocks have a marked influence on their adaptability to different soil conditions. Breeders realised very early on that the same rootstock could not be used universally on all soil types. This was another revelation in the development of rootstocks which puzzled the breeders and emphasised the need for continued breeding. Difference in rootstock performance is negligible under perfect soil physical and soil chemical conditions. Differences only become apparent under more marginal soil conditions. Limiting factors, such as shallow or compacted soils, low organic material content and the occurrence of salinity, poor drainage and excessive amounts of lime have an impact on rootstock performance.

Physical soil characteristics that influence rootstock performance include soil texture (composition of sand, silt and clay), soil structure, water retention capacity, effective depth and changing water table. Soil chemical factors include the presence of saline salts, free lime and low pH conditions, which is prevalent in especially the coastal grape growing regions of South Africa. Advances in soil preparation techniques during the 1970s increased the potential of the soil dramatically by effectively increasing the soil depth (and internal drainage) and therefore the vine’s ability to withstand adverse conditions, especially drought. Many soils that were previously considered too marginal for grape production now became suitable. With the deep application of chemical soil ameliorants such as lime (for acid soils), gypsum (for salinity) and phosphorous, soil potential was further increased. The introduction of deep soil cultivation techniques immediately meant that soils were now suitable for a wider range of rootstocks.

Viticulture in South Africa, especially in the coastal areas, is practiced on extremely old geological formations in a very high state of weathering. Most soils are low in organic matter content which, together with fine textured topsoils and heavy clay subsoils, increases the risk of compaction. Certain soils (especially from granitic origin) compact naturally, while others are sensitive because of mechanical actions (plough layers, tractor wheels, etc.). Low pH soils have a natural tendency to compact relatively easy, while lime rich soils with pH values above 7.5 (measured in potassium chloride) normally

High potential deep red Hutton soil type in Stellenbosch will induce high vigour.

This low potential Westleigh soil type with a high water table will require a rootstock with high vigour and good tolerance to subsoil wetness.

This duplex soil in Elim (Estcourt soil form) will require internal drainage and a rootstock with shallow rooting that can handle subsoil wetness and salinity.
do not. Geologically younger, less weathered calcareous deposits are found in inland areas with far fewer physical and chemical limitations to vine growth. Soil suitability will be addressed during the discussion of the commercial rootstocks.

Drought tolerance

Drought tolerance became an important consideration for the southern and south eastern wine growing regions of France that are warm and dry during summer. This applies even more so for Spain, Italy and most of the Mediterranean islands and coastal grape growing regions. The vine’s ability to tolerate drought is directly correlated to the level of branching of the root system, rooting depth and the unavailability of irrigation. With available irrigation, drought tolerance is not a consideration, unless the available irrigation water is limited. The soil’s water retention capacity is determined by the amount of clay, type of clay, stone content and organic material in the soil. Rootstock selection for drought conditions is only necessary for the coastal areas where no, or limited irrigation is available. These areas include Malmesbury, Paarl, the West Coast, Stellenbosch, Grabouw, Somerset West and Hermanus. The inland regions are almost totally irrigated.

Nematode resistance

Nematode resistance became important once grapes were grown under irrigation in warmer climates. Most research on this aspect was done in California in the United States where the San Joaquin Valley supported large areas under vines, and where damaging nematodes were prevalent, especially the *Xiphinema* species (dagger nematode) that transmits fan leaf virus. Rootstocks not only show differences in resistance to nematodes in general, but also between nematode species. The most common nematodes associated with grapevines are:

- Root knot nematodes (*Meloidogyne* species).
- Dagger nematodes (*Xiphinema index, Xiphinema italicae*).
- Root lesion nematode (*Pratylenchus vulnus*).
- Citrus nematode (*Tylenchus semipenetrans*).
- Ring nematode (*Mesocricetongaster xenoplax*).
- Spiral nematodes (*Criconemoides* species).

General nematode tolerance of rootstocks is normally presented in popular literature as resistance to the most common nematode species found on grapevine roots, namely *Meloidogyne* species (root knot nematodes). This can generally be accepted as a good indicator for broader nematode resistance of rootstocks in South Africa, but other species of nematodes are also present that should not be ignored. The soil potential and aggressiveness of the rootstock’s root system play key roles in its resistance to nematodes. The effects of nematodes on vine performance only become apparent under marginal soil conditions. Nematodes are a common pest in South Africa that necessitates the careful selection of rootstocks. Nematodes are especially active in warmer areas with sandy soils under intensive irrigation.

Soil borne fungi

Resistance against soil borne fungi like *Phytophthora cinnamomi* is important under South African conditions. This fungus is normally associated with shallow, wet soils that become saturated during the winter months under heavy rainfall, and then drain slowly during spring. It occurs naturally in the acid soils (pH < 5.5) of the coastal areas, especially where fynbos and pines grow (common on the sandstone and granitic slopes of the Drakenstein, Simonsberg and Helderberg mountains). Soil and foliage applied ameliorants like Aliette can, however, reduce the impact of *Phytophthora cinnamomi* under these conditions. *Phytophthora cinnamomi* is normally not associated with soils of higher pH. Commercial rootstocks show strong tolerance level differences.

Salinity resistance

The presence of salinity of the soil is common in South Africa, especially in the drier grape growing regions. The type of salinity should also be taken into consideration since salts like chlorides have less risk than sodium which would destabilise the soil structure. This can cause secondary problems of poor drainage and water logging. In many cases saline soils can be ameliorated by proper soil prepara-
Symptoms of root knot nematode on roots of Vitis vinifera cv Flame Seedless.

Extremely poor fruit set due to fan leaf virus infection.

Typical symptoms of Phytophthora cinnamomi on vine roots (right) and a healthy root system (left).

Climatic indicators

One aspect that is not generally accepted as a rootstock selection criterion is the adaptability of the rootstock to different climatic conditions. Climates differ from one region to the other, especially in terms of summer temperatures and relative humidity (RH). Regions with moderate temperatures during summer, but with RH of 60% or more can be considered as having a “softer” climate than areas with higher temperatures and RH of 40% or less. The rate of transpiration (cooling effect) is a function of the RH; on a very hot and dry day transpiration is much higher than on a day with higher RH. The vine is under less stress in Hermanus than in Malmesbury for example. This has a marked influence on rootstock performance, especially under dry land (unirrigated) conditions.

The same soil type under different climatic conditions will require a different rootstock choice. This is one of the reasons why Richter 99 is considered a better dry land rootstock than Richter 110 in the Swartland (with warmer and drier summers) than in Stellenbosch (with a more moderate climate) for example. The higher vigour and aggressive root system of Richter 99 is able to handle the “harsher” summer climate and drier soils better than Richter 110. The opposite
and require extensive experience of local conditions. To "harsher" climates. Climatic differences are not easily quantified (Paulsen 1103, Ruggeri 140). These rootstocks tend to be better suited branched) is utilised much more efficiently (Richter 99, Richter 110, higher vigour, because soil volume (deep root system and heavily ties (101-14, SO 4). Drought tolerance is normally associated with induced vigour, length of the vegetative cycle, will determine the time of harvest, type of trellis system, quality and quantity of the crop. This can best be explained by way of examples. Consider the following three scenarios:

- **Stellenbosch region:** Lower slopes of Helderberg, deep red soil (Hutton, Oakleaf soil form), north facing, Cabernet Sauvignon, grapes sold on open market, irrigation available. Under these conditions one should first consider the cultivar. Cabernet Sauvignon is late maturing, which is even later on the Helderberg slopes (maturation late March/early April). It is therefore important that a rootstock be chosen with a shorter vegetative cycle. Irrigation water is available which takes the necessity of a drought tolerant rootstock out of the equation. Cabernet Sauvignon is also an above average vigorous cultivar requiring a larger trellis system to accommodate the vigour. The soil in question will also increase the vigour potential. Fruitfulness can become an issue if vigour is not properly managed, therefore a rootstock that induce lower vigour should be chosen. Selling grapes on the open market in the high priced market segment requires high quality grapes, something that will be demanded by the buyer. Balanced vigour will increase quality and yield creating a win-win situation for the grower and the buyer. The rootstock option becomes obvious after taking the above into consideration.

101-14 has a shorter vegetative cycle which enables the grapes to mature earlier; it has moderate to lower vigour on a high vigour potential site, which decreases vigour and balances yield; it has poor drought tolerance, but because irrigation is available, this requirement does not play a role. If this had been a site without irrigation, Richter 110 would be the better choice (at a wider in-row spacing to accommodate the higher expected vigour).

- **Robertson region:** Sandy loam soil (Dundee soil form), intensive irrigation available, Colombar, selling grapes to cooperative cellar, application of grapes for brandy, mechanical pruning and harvesting. Under these conditions, one should consider the requirement for high yields of 30 tons/ha and more; Colombar is a late maturing cultivar; it has a low rot potential and will be harvested at 18° Brix. Attaining high yields will require a rootstock that can induce higher vigour and that can consistently produce yields of 30 tons/ha or more; the risk of a long vegetative cycle is small due to the low maturity level that is required; nematodes could be problematic in the inland growing areas under intensive irrigation on a sandy, loam soil. Ramsey would be the obvious choice due to the higher vigour that it induces, enabling the cultivar to maintain high cropping levels on a consistent basis. It has very good nematode resistance; Colombar has a low risk of rot, so the high vigour will not be problematic; the long vegetative cycle of Ramsey will not play an important role because the grapes will be harvested at a relatively low maturity level. Colombar is a naturally fruitful cultivar; therefore the higher vigour that Ramsey induces will not adversely affect long term fruitfulness.

- **Hex River region:** River bed boulders, marginal sandy soil; table grapes for export, Crimson Seedless, micro jet irrigation. Under these marginal soil conditions the need for a rootstock with high vigour is of the utmost importance. Although Crimson Seedless is one of the most vigorous table grape cultivars, a moderate vigour rootstock would not suffice to obtain the proper berry size for export grapes. The Hex River region is the latest maturing table grape region in South Africa and Crimson Seedless one of the latest maturing cultivars. Complete colouration of Crimson Seedless is of less importance because night time temperatures in the Hex River drop significantly towards the middle of April when Crimson is harvested. A high vigour rootstock with a long vegetative cycle will be an advantage to delay the maturation of the grapes for the expected higher prices at the end of the season. Ramsey would be the obvious choice, but in this case the low soil potential is the most important factor determining the rootstock choice. No other rootstock has the ability to induce ade-
quate vigour on this marginal soil type. The other characteristics of Ramsey can be “moderated” under these conditions. Vigour can be managed with irrigation and fertiliser applications, colour is not an issue due to the cold night time temperatures, delayed ripening and risk of rain (and rot) is negligible due to the high rain resistance of Crimson Seedless (as well as the possibility of plastic covering). If the soil type was loamy and rich with organic matter lower down in the valley, Richter 110 or US 8-7 would have been the better choice due to the vigour limiting effect of these rootstocks in fertile soils.

The above three examples of the thought process that should be followed for determining rootstock choice indicate the complexity of the decision. It is of greater importance than the rootstock characteristics itself. Experience of local conditions is required to make these decisions. One should have a holistic approach and be very open minded because rootstock choice is a long-term (20 - 25 year) decision.