Citrus Plant Propagation

Module 3:
Citrus Rootstocks

Learner Guide

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Citrus Growers' Association OF SOUTHERN AFRICA
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Introduction

Rootstocks are used in citrus production to take advantage of the useful traits of different citrus types and cultivars. The rough lemon cultivar, for instance, has a strong root system that makes for vigorous, large trees that produce high yields, but its fruit is not what consumers want. On the other hand, the Eureka lemon cultivar has wonderful fruit that is very popular, but its root system is not as strong as that of rough lemon. By combining a Eureka lemon scion with a rough lemon rootstock, we can take advantage of the best characteristics of both cultivars.

For this module, we visited citrus orchards with various scion and rootstock combinations, and the Citrus Foundation Block where citrus rootstock trees are cultivated for seed. Under the Citrus Improvement Scheme, nurseries can also get permission to harvest their own seed for rootstock production, for which they need to have full-grown trees of rootstock varieties. Most seeds used in nurseries are however sourced from the Citrus Foundation Block.

You will not see these rootstock trees on a commercial citrus farm, of course, because the fruit is not marketable. It is however useful to look at fully grown rootstock trees, as they show most clearly those traits that make them desirable as rootstocks. It is also useful to study the characteristics of their leaves and trunks so that we are able to identify the rootstocks used in existing plantings where there are no accurate records.

Rootstock Selection

How do we go about selecting the right rootstock for the fruit-bearing cultivar and for the conditions on our farm? There are three factors we need to keep in mind when selecting the rootstock.

First and foremost, the rootstock must be compatible with the fruit-bearing variety. Much research is done on rootstock and scion compatibility, and it is important to review the most recent findings before taking a final decision. We will say more about the signs and impact of incompatibility a little later.

Secondly, a rootstock must be selected with the eye on minimising the effect of limitations that there might be at the site, such as the soil type, the quality of the irrigation water, and the prevalence of pests and diseases. Lastly, the right rootstock can enhance the tree vigour, and the yield, fruit size and fruit quality.

Rootstock-Scion Compatibility

During propagation two plants with different genetic makeups are combined to make a citrus tree, one being the rootstock and one the fruit-bearing scion. For the trees to grow well, the two plants have to be genetically compatible, and have to be able to integrate well enough to ensure that metabolic processes in the plant and the transportation of water and nutrients through the plant is optimal.

The affinity or compatibility between the rootstock and the scion is fundamentally important. If the tree continues to grow without difficulty, it is considered a compatible union. But not all citrus species are compatible with each other. Research into rootstock and scion compatibility, mostly in the form of field trials, is continually conducted in various climatic and growing conditions.

In most cases, incompatibility is evident at a young age, with trees showing bud-union deformity or low growth rates from the outset. There are however cases where incompatibility only becomes evident when the trees are already mature, and then goes into decline.

Such sudden tree decline can be due to a number of other factors as well, including suboptimal plant nutrition, water shortage, disease infection or pest infestation, but incompatibility must be investigated as one of the possible causes. Remove a strip of bark from the bud union of the tree. If there is a brown line between the rootstock and scion, it is a sign of incompatibility.

Bud union deformity is also seen to be a sign of incompatibility. Rootstock overgrowth, or benching, is a common deformity, and occurs with rootstocks of trifoliate orange parenting. Benching may reduce the lifespan of the tree because it causes compression girdling. In most instances, though, it does not seem to have a serious effect.

Identifying Rootstocks

On most farms excellent records are kept of the plantings on the farm, including details about the rootstock used in every orchard. Where records are however no longer available, it will be necessary to identify the rootstock used in an established orchard.

Rootstocks have distinguishing characteristics by which they can be identified, such as its colour, the smoothness of its bark, the bud union, and its leaf shape. To identify it by the leaves, you will need to find a tree that has water shoots bearing leaves growing out of the rootstock.

Correctly identifying the rootstock can be challenging, and it is best to consult a specialist in this regard.

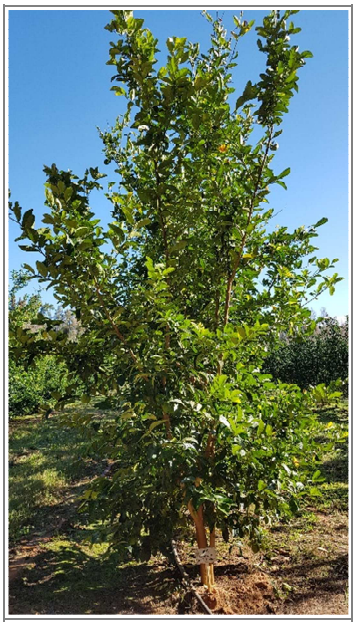
Common Rootstocks

Let's now look at the most common rootstocks used in South Africa, and their characteristics.

Rough Lemon

Rough lemon is probably the best-known citrus rootstock and is still widely used. It is presumed to be indigenous to north-east India, where it still grows wild. This is a mature rough lemon tree, from which you can see the exceptional tree vigour. This is what the leaves and trunk of a rough lemon tree look like.

Rough lemon is known as one of the most vigorous rootstocks, developing large tree size, and producing medium to large fruit with a good crop load.



Rough lemon tree

Tree Characteristics

Trees on rough lemon rank at or near the top in terms of growth vigour and tree size in comparison with trees on other rootstocks, provided that soils are disease-free, specifically of nematodes and *Phytophthora*. Trees are more sensitive to cold and frost damage, but young trees that have been damaged by cold recover more rapidly than trees on less vigorous rootstocks.

Fruit Characteristics

Trees on rough lemon produce excellent crops with generally large fruit size. The internal quality of the fruit is moderate with lower sugar, juice and acid levels than is the case with quality-inducing rootstocks. The fruit also tend to have a relatively thick rind, and juice quantity and quality is among the poorest compared to other rootstocks. Fruit from trees on rough lemon does not hang as well as on some other rootstocks, with the flesh tending to dry out and to become granulated.

Planting Conditions

Rough lemon can be planted in a wide range of soils, but it is particularly well adapted to deep, coarse sands on which some other rootstocks do not perform well. Rough lemon is not tolerant of root rot and should not to be used on wet, poorly-drained soils, even though it is more tolerant of flooding than most rootstocks. Rough lemon tolerates calcareous soils with a pH above 7.5, but is sensitive to very saline soil conditions. Rough lemon is regarded as a poor replant rootstock, but there are treatments available with which it can possibly perform adequately, provided that irrigation is carefully controlled.

Pest and Disease Tolerance

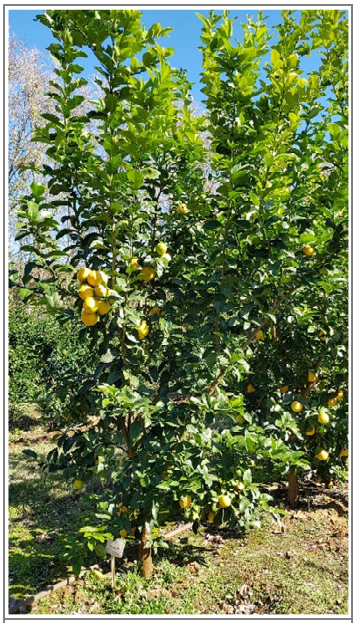
Trees on rough lemon are tolerant of Citrus tristeza virus and exocortis. They are susceptible to citrus nematodes and are severely affected by *Phytophthora* root rot. High susceptibility to citrus blight is another major weakness of rough lemon and this has affected the extent of its use in South Africa.

Cultivar Options

Eureka lemon in combination with rough lemon performs very well and still remains the primary choice, except on replant and heavy soil types. Rough lemon is also an excellent rootstock for oranges. Some Valencia cultivars have an inherently high juice quality and propagating them on rough lemon does not greatly reduce their quality. These cultivars usually yield best on rough lemon, though Brix will be lower.

Rough lemon is however not a good rootstock for mandarins because the fruit tend to granulate, reducing the already short harvest season of most mandarin cultivars. The alternate bearing tendency of mandarin cultivars may also be enhanced if rough lemon is used as rootstock.

Volckameriana



Volckameriana tree

The Volckameriana rootstock is of Italian origin and is thought to be a natural hybrid of lemon and sour orange. It resembles rough lemon in many respects, but in areas where it is used widely it is not considered an improvement on rough lemon.

This is a mature Volckameriana tree, and this is what the leaves and trunk look like.

Tree Characteristics

As is the case with rough lemon, Volckameriana gives rise to vigorous, large trees. Trees are however less affected by cold than those on rough lemon.

Fruit Characteristics

As with rough lemon, trees on Volckameriana produce a good crop of large fruit, but the internal quality is below average in terms of sugar, juice and acid levels. Fruit also tend to have thicker rinds, and they are prone to granulation if left hanging on the tree.

Planting Conditions

Similar to rough lemon, Volckameriana is adapted to a fairly wide range of soil conditions, and is less susceptible to *Phytophthora* root rot than rough lemon.

Pest and Disease Tolerance

Volckameriana is not susceptible to exocortis, but is damaged by citrus nematodes and sensitive to the Citrus tristeza virus. Trees on Volckameriana are affected by citrus blight and seem to be as susceptible as those on rough lemon.

Cultivar Options

In South Africa the performance of Volckameriana as a rootstock for lemons has been excellent. It has also performed well in combination with grapefruit, Valencia and navel types, but its use in combination with these cultivars is no longer recommended due to its sensitivity to Citrus tristeza virus.

Cleopatra Mandarin

The Cleopatra mandarin originated in India and was introduced into Florida from Jamaica in the mid-nineteenth century. It has been distributed and tested around the world. As is the case with rough lemon and sour orange, its performance as a rootstock has been studied over many years.

Cleopatra has had limited use as a rootstock, but it remains a good option, considering the importance of tolerance to Citrus tristeza virus, blight and salinity, which outweighs the disadvantages of yield and fruit size. This is a mature Cleopatra mandarin tree, and this is what its leaves and trunk look like.

Tree Characteristics

The growth of trees on Cleopatra is good, producing trees of an average to large size. It is, however, a "lazy" rootstock in that while the trees grow well, they fruit relatively poorly until they are eight to ten years old.

Fruit Characteristics

Trees on Cleopatra produce fruit of good quality, similar to the citranges, but the fruit tend to be on the small side, especially in combination with Valencia types.

Planting Conditions

Trees on Cleopatra are tolerant of cold conditions. Cleopatra has a relatively deep root system, and is quite well-adapted to dry conditions, which makes it somewhat drought tolerant. Cleopatra has the highest salinity tolerance of all commercial rootstocks. It does well on deep, loamy, well-drained soils, but is adversely affected by soils with high water tables.

Pest and Disease Tolerance

Trees on Cleopatra are unaffected by Citrus tristeza virus and exocortis, and fairly tolerant of *Phytophthora* root rot. Cleopatra is susceptible to citrus nematodes.

Cleopatra ranks as one of the most tolerant rootstocks to citrus blight. Trees only become affected at an advanced age, which makes Cleopatra a good option for inter-planting in orchards affected by blight.

Cultivar Options

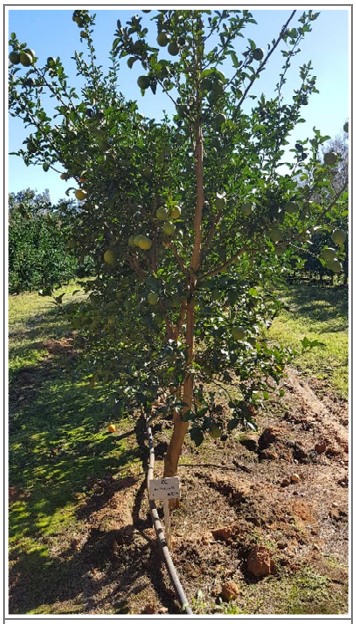
Because of the smaller fruit size, Cleopatra is not considered ideal for use with Valencia types. It has been used with success in combination with navels, where smaller fruit size is less of a disadvantage. Cleopatra also performs well with grapefruit, Eureka lemon and mandarin cultivars with large fruit.

Carrizo and Troyer Citrange

Hybrids of sweet orange and trifoliate orange are known as citranges. Carrizo and Troyer are hybrids of Washington Navel orange and *Poncirus* trifoliata. Carrizo and Troyer citranges are visually indistinguishable.

The main difference between the two is that Carrizo is resistant to the burrowing nematode, a nematode not present in southern Africa. In the past, Troyer was widely used in South Africa, but Carrizo has now become more popular.

These are mature citrange trees. Note the trifoliate leaf formation. This is what the trunk of a citrange rootstock look like.



Carrizo Citrange tree

Tree Characteristics

Trees on Carrizo and Troyer tend to be large, but smaller than those on Swingle citrumelo. Characteristic of these rootstocks is the excellent performance of young trees, both in terms of vigorous growth and producing excellent crops of high quality fruit.

Fruit Characteristics

Fruit size is usually medium to large and internal fruit quality is excellent. A major disadvantage is the tendency to induce a higher incidence of creasing when used in combination with sensitive cultivars.

Carrizo and Troyer also induce higher acid levels than rough lemon, which may be a problem in the cooler production areas, but can be an advantage in hotter areas. Colour development of fruit is usually five to ten days ahead of that on Swingle or rough lemon.

Planting Conditions

Carrizo performs far better in replant orchards than rough lemon. Carrizo and Troyer are sensitive to alkaline-induced chlorosis and in some cases trees have severely declined as a result of iron and other trace element deficiencies on saline, calcareous and especially high pH soils.

Carrizo and Troyer have a less-developed feeder root system than rough lemon and are therefore not as tolerant of low soil moisture levels. Irrigation regimes must be adjusted to take this into account.

Pest and Disease Tolerance

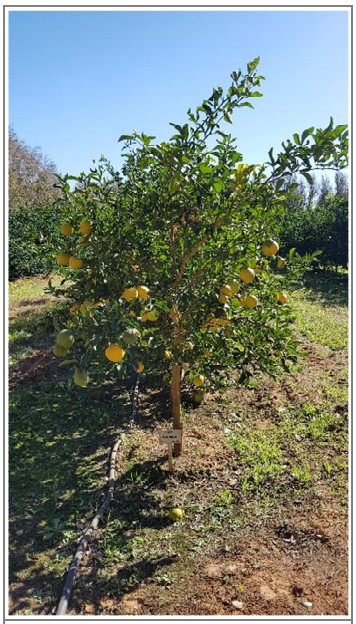
Carrizo and Troyer inherited their susceptibility to citrus viroids from the trifoliate orange parentage. Carrizo and Troyer are ranked as tolerant of *Phytophthora* root rot, Citrus tristeza virus and citrus nematodes.

Trees on Carrizo and Troyer appear somewhat susceptible to Fusarium dry rot decline, and are affected by citrus blight.

Cultivar Options

Carrizo and Troyer are excellent rootstocks for sweet orange and grapefruit cultivars, and for most mandarin hybrids, with midknight Valencia in combination with Carrizo citrange considered a particularly good combination. It is not compatible with Eureka lemon.

Swingle Citrumelo



Swingle Citrumelo tree

Hybrids of grapefruit and trifoliate orange are known as citrumelos. There are many named and unnamed citrumelos, but Swingle citrumelo has been the most widely planted.

In South Africa, Swingle became popular during the 1990s, but its popularity has decreased since due to preferences shown for Carrizo citrange.

This is a mature Swingle tree. Note that it also has a trifoliate leaf. This is what the trunk looks like.

Tree Characteristics

Swingle produces large, vigorous and productive trees. In their first five years, trees on Swingle have similar growth to trees on Carrizo, regardless of scion. The Swingle tree itself is very cold tolerant and trees on Swingle perform better than those on Carrizo citrange or rough lemon in this respect.

Swingle tends to overgrow the scion at the bud union, also referred to as benching. This can cause compression girdling and affect tree performance. Overgrowth has been seen in combination with mandarin types, and with most orange cultivars. It seems to be linked to tree vigour and stem diameter, which means that where tree size is being managed the problem is less prevalent. A higher bud union also reduces the problem.

Fruit Characteristics

Trees on Swingle citrumelo produce high yields of large-sized fruit with excellent internal quality, but fruit size tends to be smaller where crop load is excessive. Rind colour development and late fruit maturity may be delayed due to higher acidity, with acid levels being higher in fruit in cooler production areas. Swingle is prone to cause creasing in scion fruit.

Planting Conditions

Swingle citrumelo is a suitable rootstock for most soils except heavy clay, with a clay content greater than twenty-five to thirty percent possibly restricting root growth. Trees on Swingle are more sensitive to calcareous conditions and subject to lime-induced chlorosis, for which iron chelates can be added to the soil.

pH adjustment to between 5.8 and 6.2 through regular fertigation applications can overcome iron chlorosis on heavy, calcareous soils. Trees on Swingle are more salt tolerant than other trifoliate hybrids. The trees are also moderately drought tolerant, and resistant to cold damage.

Pest and Disease Tolerance

Swingle is classified as resistant to *Phytophthora* root rot, and is tolerant of the citrus nematode and Citrus tristeza virus. Swingle is sensitive to citrus exocortis viroid and to Armillaria, a fungal disease which affects the rootstock just beneath the soil surface.

Cultivar Options

Swingle is a superior grapefruit and Minneola tangelo rootstock, although problems with higher fruit acidity levels occur in the cooler areas. It also works well with Valencia and navel scions. Limited information is available on this rootstock in combination with mandarins, although certain tangors and clementines have performed well. Swingle is incompatible with Eureka lemons, with Tomango and Shamouti midseason cultivars, and with Murcott mandarin.

C35 Citrange

C35 citrange was developed in California and is a cross between Ruby sweet orange and *Poncirus* trifoliate orange. Trees on C35 citrange are very productive, producing good-sized fruit with high internal quality. As a result, C35 has become very popular amongst Californian growers and is now one of their leading rootstocks. This is a mature C35 tree. Note the shape of the leaves. This is the trunk of the C35 rootstock.

Swingle Citrumelo tree

Tree Characteristics

Trees on C35 grow at the same rate as those on Carrizo and Troyer citranges up to about six years of age, at which stage growth slows down with the eventual mature tree size being fifteen to twenty-five percent smaller. Ten years after planting, the tree will be a third smaller in size compared to a tree on Swingle citrumelo. Trees on C35 is less cold resistant than those on Swingle and Carrizo.

C35 has a lower percentage of nucellus seedlings than other citranges. Because of its popularity, demand for seed long outstripped supply. The seed shortage, combined with a high demand for seedlings, led to a situation where seedling culling in the nurseries was insufficient. This resulted in off-type or zygotic seedlings being included in new plantings, resulting in incompatibilities and dieback, as well as poor uniformity in orchards. To produce good quality trees, selection of C35 seedlings in the nursery is therefore very important, where up to thirty percent or higher seedling culling might be necessary.

Fruit Characteristics

Trees on C35 produce very good quality fruit with high internal quality early in the season. Larger fruit size and high yields remain some of the better qualities of this rootstock. As an example, Star Ruby trees on C35 have been recorded as peaking at a hundred kilograms per tree from year seven onwards.

Planting Conditions

As with Carrizo and Troyer, C35 does not adapt well to saline and high pH soils. C35 also performs below average when planted on soil that is very sandy or has a high clay content, and its performance on replant soils is average.

Pest and Disease Tolerance

C35 is tolerant of citrus nematodes and Citrus tristeza virus, and has intermediate resistance to *Phytophthora* root rot. It is sensitive to citrus exocortis viroid and has been found to be sensitive to citrus blight during trials.

Cultivar Options

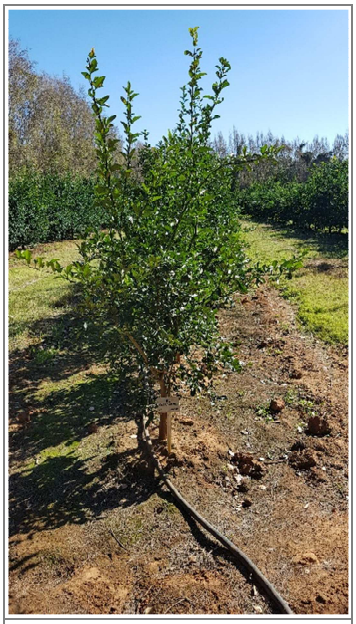
C35 has performed well in trials in combination with grapefruit, navels, most Valencia and mandarin types, but has shown incompatibility with Turkey Valencias, Nules Clementine and Fukumoto Navel. In general, there appears to be more incompatibility problems with C35 than with the other rootstocks.

Benton Citrange

Benton citrange is a promising new rootstock that was bred in Australia, in an attempt to produce rootstocks compatible with Eureka lemon. It is a hybrid of Ruby Blood orange and trifoliate.

Benton has been used for commercial Eureka plantings in Australia since 1990, where it proved to be both Citrus tristeza virus and *Phytophthora* tolerant. Benton has been tested in South Africa as a rootstock for Eureka lemon.

This is a mature Benton tree, and this is what the leaves and trunk look like.



Swingle Citrumelo tree

Tree Characteristics

Trees on Benton are more compact than trees on rough lemon, Swingle and Carrizo, resulting in more manageable trees, closer spacing and higher production per hectare. Trees grow less vigorously than those on Swingle citrumelo. In the nursery, the rootstock tree has a bushy growth habit with a shrub-like appearance. Trees on Benton also show a good tolerance to drought and cold conditions.

Fruit Characteristics

For Valencia types, Benton produces very good quality fruit with high internal quality early in the season. Medium to larger fruit size remains one of the more favourable traits of this rootstock. A trial of Midknight Valencia on Benton in the Letsitele area produced an average crop of over eighty kilograms per tree.

Planting Conditions

Benton is sensitive to saline and calcareous soils. It outperforms most other rootstocks on replant soil.

Pest and Disease Tolerance

Benton shows intermediate resistance to *Phytophthora* root rot, nematodes and Citrus tristeza virus.

Cultivar Options

Benton is compatible with Eureka lemon and this combination has shown good crop production and fruit size. It is also showing promise in combination with grapefruit, Valencia, Navel and mandarin types. In a rootstock trial in Letsitele it was found to be the best rootstock option in combination with Midknight Valencia in terms of yield, fruit size, internal quality and external colour development.

X639 Hybrid

The X639 rootstock arose from a cross between Cleopatra mandarin and *Poncirus* trifoliate and was bred in South Africa. This is a mature X639 tree. This is what the leaves and trunk look like.

Tree Characteristics

Trees on X639 are less vigorous than those on Swingle citrumelo, and more similar to Carrizo citrange, with a fairly smooth bud-union between the scion and rootstock. X639 develops a medium-sized tree in combination with most scion cultivars. Trees on X639 show good cold hardiness.

Fruit Characteristics

X639 is capable of inducing good internal fruit quality and of producing fair yields of good-sized fruit. High levels of creasing of fruit on this rootstock are occasionally reported, and it is best to scion cultivars that are not susceptible to creasing.

Planting Conditions

X639 performs well on higher pH soils and is suitable for most soils except in extremely calcareous conditions. It performs particularly well on loamy soils and where fruit with a high internal quality is required.

Pest and Disease Tolerance

X639 is tolerant of *Phytophthora* root rot and Citrus tristeza virus, but highly susceptible to citrus viroids. Trees on X639 are susceptible to citrus blight, but take about twelve years to show decline.

Cultivar Options

X639 is compatible with Eureka lemons. This combination has performed very well on replant soils. X639 is a rootstock with promise for other cultivars as well, seemingly well-suited to grapefruit and with no apparent problems in combination with Valencias, navels and mandarins. It is considered a very good option for Midknight Valencia.

Minneola x Trifoliate Hybrid (MxT)

MxT is a hybrid of minneola tangelo, itself a cross between a grapefruit and a tangerine, and a trifoliate orange. This is a mature MxT tree. Note the trifoliate shape of the leaf. This is what the trunk of an MxT rootstock tree looks like.

Tree Characteristics

MxT is a vigorous rootstock plant in the nursery, but once budded, it controls the size of the scion. Mature trees on MxT are slightly smaller than those on Swingle and Carrizo.

Fruit Characteristics

Trees on MxT have excellent yield per tree, and the internal fruit quality is high.

Planting Conditions

The adaptability of MxT to various soil conditions is not well-known, but it seems as if it does not adapt well to soils with a high pH. It is suitable for replant soils.

Pest and Disease Tolerance

MxT is sensitive to exocortis, but tolerant of Citrus tristeza virus, *Phytophthora* root rot and citrus nematodes.

Cultivar Options

MxT is compatible with most scion varieties, and performs well with Eureka lemons. It is incompatible with Kumquat cultivars.

US-812 (Sunki x Benecke)

The Sunki Benecke rootstock is a hybrid of Sunki mandarin and Benecke trifoliate orange, and was developed in the USA. It has been commercially available since 2001. Sunki Benecke is still relatively new in South Africa and has not been extensively tested with different cultivars under different growing conditions. This is a mature Sunki Benecke tree. This is what the leaf and trunk of the Sunki Benecke looks like.

Tree Characteristics

The average size of trees on Sunki Benecke is medium to large, except for Star Ruby which has a compact tree size.

Fruit Characteristics

Trees on Sunki Benecke produce high yields from a young tree age. The fruit is medium in size with good to excellent internal quality. Trials with Delta and Midknight Valencia have produced an average crop of over a hundred kilograms per tree.

Planting Conditions

Sunki Benecke was selected as a rootstock option because of its tolerance to high pH and calcareous soils and generally performs well in most replant conditions.

Pest and Disease Tolerance

Sunki Benecke is resistant to *Phytophthora* root rot and tolerant of nematodes, Citrus tristeza virus and blight, but is expected to be sensitive to citrus exocortis.

Cultivar Options

Sunki Benecke is compatible with Eureka lemons, and is a promising new rootstock which can be used on a semi-commercial scale in combination with grapefruit, Valencia, Navel and mandarin types.

Conclusion

The choice of the right rootstock can be critical to the ultimate success of the citrus farm. It is therefore important that you make your decision after careful consideration and obtaining the advice from cultivar experts and the citrus nursery. Citrus Research International and the Citrus Improvement Scheme are excellent sources of information on rootstocks, and can advise on the latest research findings.