



NSW DEPARTMENT OF
PRIMARY INDUSTRIES

Growing lemons in Australia- a production manual - Readers' Note

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<http://www.dpi.nsw.gov.au/agriculture/horticulture/citrus/lemon-manual>

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Severe overgrowth of Verna on Fraser rootstock

INTRODUCTION

All commercial lemon varieties in Australia are budded onto selected rootstocks. The decision about which rootstock to use has important long-term effects on the potential life and profitability of plantings. Some scion rootstock combinations are incompatible. With lemons the most well known is the incompatibility of Eureka lemon on *Poncirus trifoliata*, Troyer and Carrizo citranges and Swingle citrumelo. No single rootstock is suitable for all sites or for all varieties. As a result, take great care in selecting the best rootstock for the soil, growing conditions and the markets being targeted.

The ideal rootstock is likely to vary with the soil type, depth and previous land use. The variety and clone of lemons to be grown is sometimes also an important factor. Rootstock can effect both time of harvest and fruit quality, and both of these factors can have a big effect on dollar returns. Rootstock can have a large effect on many aspects of production including yield, fruit quality, tree size, tolerance to salts and diseases, and scion compatibility. The general tolerance and fruit quality effects of various citrus rootstocks (although not specifically detailed for lemons) is detailed in Tables 1, 2 and 3.

General rootstock information sheets are contained at the end of this section.

Table 1: The relative tolerance of citrus rootstocks to nematodes and diseases

| Rootstock | Phytophthora tolerance | Tristeza tolerance | Exocortis tolerance | Citrus nematode |
|----------------------|------------------------|--------------------|---------------------|-----------------|
| <i>P. trifoliata</i> | 1 | 1 | 5 | 1 |
| Swingle citrumelo | 2 | 1 | 2 | 1 |
| Troyer citrange | 2 | 1 | 4 | 3 |
| Carrizo citrange | 2 | 1 | 4 | 3 |
| Benton citrange | 2 | 1 | 4? | 3? |
| Cleopatra mandarin | 3 | 1 | 1 | 4 |
| Rough lemon | 4 | 2 | 1 | 4 |
| Sweet orange | 5 | 2 | 1 | 4 |

Key: 1 = best of rootstocks listed; 5 = worst of rootstocks listed; ? = uncertain.

Table 2: The relative tolerance of citrus rootstocks to salinity and soil types

| Rootstock | Salinity | Calcium (Alkalinity) | Soils | | |
|----------------------|----------|----------------------|-------|------|----------------|
| | | | Sandy | Loam | Poorly drained |
| <i>P. trifoliata</i> | 5 | 5 | 2 | 2 | 1 |
| Carrizo citrange | 3 | 4 | 2 | 2 | 2 |
| Troyer citrange | 3 | 4 | 2 | 2 | 2 |
| Benton citrange | 4 | 4 | 2 | 2 | 2 |
| Swingle citrumelo | 2 | 4 | 2 | 2 | 1 |
| Rough lemon | 4 | 3 | 1 | 3 | 5 |
| Sweet orange | 3 | 2 | 2 | 1 | 4 |
| Cleopatra mandarin | 1 | 1 | 3 | 2 | 3 |

Key: 1 = best of rootstocks listed; 5 = worst of rootstocks listed

Table 3: General effects of citrus rootstocks on fruit quality

| Quality Characteristic | Troyer/Carrizo citranges | Rough lemon | Sweet orange | Cleopatra mandarin | Swingle citrumelo | <i>P. trifoliata</i> |
|----------------------------|--------------------------|-------------|--------------|--------------------|-------------------|----------------------|
| Fruit Size | medium | Large | medium | small-med | med-large | med-large |
| Rind Thickness | thin | Thick | medium | thin | thin | thin |
| Rind Texture | smooth | Coarse | medium | medium | smooth | smooth |
| Fruit Maturity | mid | Early | mid | mid | mid-late | mid-late |
| Total Soluble Solids (TSS) | high | Low | medium | medium | high | high |
| Acid Content | medium-high | Low | medium | medium | medium | high |
| Juice Content | high | Low-med | medium | med-high | high | high |

Rootstocks and their main characteristics

Benton citrange. Benton citrange was released to industry in 1985 and commercial plantings using this rootstock have gradually increased since the early 1990's. It has performed well in replant soils and is the only citrange selection which can be used under Eureka lemon without inducing severe incompatibility. The research at Renmark showed that it is also very successful in virgin soils.

Citrus volkameriana. *C. volkameriana* is being used as an alternative rootstock for lemons and has similar characteristics to Rough lemon. Trees are large and vigorous with lower yields than Rough lemon and with generally poor fruit quality characteristics. It has some resistance to *Phytophthora* root rot being slightly better than Rough lemon.

Cleopatra mandarin. Cleopatra tends to produce most of its roots near the soil surface and could be considered for shallow soil situations (on mounded rows), especially if the subsoil is high in free lime (calcium carbonate).

Cox mandarin hybrid (3798). Cox is a Scarlet mandarin x *P. trifoliata* hybrid bred by NSW Agriculture and released commercially in 1995. It is resistant to *Phytophthora* root and collar rots and has shown promise in screening trials as a rootstock for Eureka lemon with no signs of the bud union incompatibility. Cox has relatively seedy fruit and produces uniform, moderately vigorous seedlings in the nursery. This variety is now being used commercially.

Fraser Seville hybrid (4017) is a Smooth Seville x *P. trifoliata* hybrid bred by NSW Agriculture and released commercially in 1995. It is resistant to *Phytophthora* root and collar rot. It was recently assessed as a rootstock for Fino, Verna and Eureka at two Australian sites and shows little promise as a commercial rootstock for lemons.

Nelspruit hybrid 639 is a Cleopatra mandarin x *P. trifoliata* hybrid bred in South Africa. It has performed well as a rootstock for Eureka lemon at the Gosford trial site producing fruit with a higher percentage of juice and citric acid than that grown on Rough lemon rootstock. Nelspruit hybrid has shown moderate susceptibility to *Phytophthora* and hence its use would be better confined to virgin, well-drained sites.

Poncirus trifoliata. It is incompatible with Eureka lemon. This is not a preferred rootstock for South Australian growing conditions because of its

Rootstocks

low tolerance to soils high in lime and to saline irrigation water. If used, for example in clay soils near Renmark for the growing of Lisbon lemons, it would produce high quality fruit.

Rough lemon. Rough lemon is a very good rootstock for producing large healthy trees, however, it tends to produce fruit rough in texture and lower in juice. These negative effects could be at least partly countered by adjusting nutrition programs but rough lemon also tends to produce larger fruit with thicker skins. Trees are more prone to damage from root diseases, nematodes and water logging. Mature fruit can be stored, “on tree” for less time, compared with other rootstocks.

Rough lemon is best suited to virgin soils and should not be used in replant soils. In replant soils Benton citrange, Cox mandarin hybrid or Troyer citrange (incompatible with Eureka lemon) should be considered.

Sweet orange. This is an excellent rootstock for soils that have not previously been cropped with citrus. If soils have adequate depth and are free draining, sweet orange enhances yield and fruit quality, and “on tree” storage of fruit. Because of its susceptibility to root rots and nematodes, it is not recommended for replant situations.

Swingle citrumelo. This rootstock is relatively new in Australia. It has performed very well under grapefruit, well under oranges when they are not grown on poor or highly calcareous soils but there is not much known about its performance under lemons. It is incompatible with Eureka lemon. Although Swingle produces very well in many soil types, it is reported that it performs poorly in soils high in lime. It is superior to the citranges in its tolerance to water logging and nematodes and similar in its tolerance to root rots and soils high in lime.

Troyer and Carrizo citranges. These rootstocks cannot be used with Eureka lemon due to incompatibility problems. When using Lisbon or other varieties there are small but significant differences in performance between these two rootstocks. Both are suited to replant soils where calcium (free lime) levels are not high and both have good tolerance to nematodes, *Phytophthora* and other replant diseases. They are inferior to Rough lemon and *C. volkameriana* for translocation of soil water from the roots to the leaves and fruit. Citrange rootstocks tend to produce smaller fruit.

Key References

Barkley, P. **National Citrus Nursery Workshop Proceedings**, Mildura, Australia, 19-20 June 2002.

Castle, W. S., Tucker, D. P. H., Krezdorn, A. H. and Youtsey C. O. **Rootstocks for Florida Citrus**. 1993.

Ballasch, P. T., and Staniford, M. **Citrus Varieties and Rootstocks for the Riverland**. 2003.

Forsyth, J. B. and Barkley, P. **Citrus Rootstocks Agfact H2.2.2. NSW Agriculture**. 1989.

Lemon Variety Rootstock Compatibility Chart

| Rootstock | Eureka | Fino | Lisbon | Meyer | Verna | Yen Ben |
|------------------------------|--------|------|--------|-------|-------|---------|
| Benton citrange | ✓ | ✓ | ✓ | ✓? | ✓* | ✓ |
| Carrizo citrange | × | ✓? | ✓ | ✓? | ✓ | NR |
| Nelspruit hybrid 639 | ✓ | ✓ | ? | ? | ✓ | ✓** |
| Cox mandarin hybrid (3798) | ✓ | ✓ | ? | ? | ✓ | ? |
| Fraser seville hybrid (4017) | ✓ | ✓ | ? | ? | ✓* | |
| <i>P. trifoliata</i> | × | ✓ | ✓ | ✓ | ✓ | ✓ |
| Rough lemon | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |
| Sour orange | ✓ | ✓ | ✓? | ? | ? | ? |
| Swingle citrumelo | × | | ✓ | × | | × |
| Sweet orange | ✓ | ✓ | ✓ | ✓ | ✓ | NR |
| Troyer citrange | × | ✓? | ✓ | ✓? | ✓ | × |
| <i>C. volkameriana</i> | ✓ | ✓ | ✓ | ✓ | ✓* | ✓ |
| Schaub Rough lemon | ✓ | ✓* | ✓? | ? | ✓* | ? |
| C35 citrange | × | ? | ? | ? | ? | × |

✓* Some overgrowth of the bud union observed (at the three Australian trial sites) - longterm compatibility unknown at this stage.
 ✓ Compatible
 × Incompatible
 ✓** Overgrowth in New Zealand trials
 ✓? Longterm compatibility in Australia unknown
 ? Compatibility unknown under Australian conditions
 NR Not recommended



Photo by April Winchel
Severe rootstock suckering can be a sign of incompatibility



Photo by April Winchel
An example of incompatibility - overgrowth of the scion

Rootstock Characteristics Table

| Stock | Characteristics | Requirements | Major risk factors |
|-----------------------------|--|---|--|
| Benton citrange | Resistant to <i>Phytophthora</i> root and collar rots. Compatible with Eureka lemon. With Eureka produces trees of intermediate size and good cropping efficiency. Exocortis-free budwood. | Not suitable for calcareous soils. | Tolerance to nematodes unknown. |
| Cleopatra mandarin | Moderately susceptible to <i>Phytophthora</i> root and collar rots. Tristeza and exocortis tolerant. Susceptible to citrus nematode. Intermediate depth of rooting; intensive fibrous root development. Slow growing in nursery, mature trees large. Early production poor, satisfactory in mature trees. Good fruit quality but small fruit size with some cultivars. | Performs well on both heavy and light soils; best suited to loams. Lime and salinity tolerant. | Tendency to small fruit size. Good drainage and precautions against root rot essential. Slow to come into bearing. |
| <i>P. trifoliata</i> | Highly resistant to <i>Phytophthora</i> , tristeza and citrus nematode. Cold hardy. Intolerant of exocortis. Shallow depth of rooting but develops high fibrous root density. Tree size small to medium. Generally highly fruitful. Fruit quality very good. | Exocortis and latter leaf free bud wood. Will grow on wide range of soils, but prefers loams. Intolerant of highly acid and lime soils. Poor drought tolerance. | Incompatible with Eureka lemon and acidless oranges. Compatibility with some minor varieties unknown. Despite accumulating high levels of chloride in leaf tissue does not exhibit obvious toxicity symptoms until leaves drop. Prone to sudden death. |
| Rough lemon (citronelle) | Susceptible to <i>Phytophthora</i> root and collar rots, citrus nematode. Tristeza and exocortis tolerant. Mycorrhizal dependent. Extensive lateral and vertical root development. Highly drought tolerant. Produces large trees. Yields are high, of good fruit size, but poor quality. Promotes early maturity. | Best on deep virgin sandy soils. | Does not tolerate poorly drained soils. Tendency to accumulate excessive chloride leading to leaf drop. Unsuitable for some mandarins eg. Satsuma and Ellendale tangor. |
| Sweet orange | Very susceptible to <i>Phytophthora</i> root and collar rots; susceptible to citrus nematode. Tristeza and exocortis tolerant. Mycorrhizal dependent. Intermediate depth of rooting. On well-drained soils in inland areas produces large trees. High yielding with good fruit quality. | Best on deep sandy soils. Sensitive to dry conditions but tolerates calcareous soils. | Does not tolerate excessive soil moisture. |
| Swingle citrumelo | <i>Phytophthora</i> and drought tolerant; nematode resistant; tristeza tolerant. More salt tolerant than other <i>P. trifoliata</i> hybrids. Good fruit quality. | Not suited to clay or highly calcareous soils | Has tolerance to water logging. Incompatible with Eureka lemon and some orange and mandarin cultivars. Overgrows orange varieties. Fruit more prone to creasing than Rough lemon. |
| Troyer and Carrizo citrange | Resistant to <i>Phytophthora</i> , cold hardy. Tristeza tolerant; infection by exocortis results in reduced tree size, but no butt scaling. Mycorrhizal dependent. Intermediate depth of rooting; main lateral and fibrous root development may be poor in young trees. Medium to large trees, usually very productive with good fruit quality | Exocortis-free budwood. Adapted to wide range of soil types, except highly calcareous soils. | Incompatible with Eureka lemon. Very prone to micronutrient deficiencies, especially on calcareous soils. Compatibility with some minor varieties unknown. Prone to sudden death. |

Source: “Know your Rootstocks” K. Bevington, NSW Agriculture, Dareton.