# RECENT ADVANCES IN THE STUDY OF EXOCORTIS (SCALY BUTT) IN AUSTRALIA

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## INTRODUCTION

Research in New South Wales into the use of *Poncirus trifoliata* (Linn.) Raf. as a stock for commercial varieties of citrus is directed by the Citrus Improvement Committee of the New South Wales Department of Agriculture, consisting of Dr. Lilian R. Fraser, Plant Pathologist, and a group of horticultural officers, the personnel of which has changed over the years. At first there were Mr. R. J. Benton and Dr. F. T. Bowman; later, Mr. R. G. Kebby followed Mr. Benton and was himself replaced by Mr. E. C. Levitt. With Dr. Bowman's appointment to the position of Chief of the Division of Horticulture, New South Wales Department of Agriculture, he left the committee, which now consists of two members, Dr. Fraser and Mr. Levitt.

The committee was set up in 1944 with the object of finding the cause of the butt-scaling disease of *Poncirus trifoliata*, which was limiting the use of this valuable stock at a time when its use was becoming increasingly desirable because of its immunity to Phytophthora root rot.

Because of the long delay in symptom development, it was not until 1948 that evidence started to accumulate that the disease was caused by a bud-transmitted virus, symptomless in the common commercial varieties and stocks but causing scaling of the butt and stunting of scions when grown on *Poncirus trifoliata* stock (*1*, *2*).

The present objective of the committee's work is the practical one of obtaining the best scion and stock selections of the citrus varieties in common use for the production of satisfactory orchard trees. This involves, in addition to virus investigation, trial of rootstock selections and comparative trials of virus-free scion selections of good agronomic type.

During the past 10 years investigations have been made along several lines, some based mainly on field observations and others based on experimental propagations aimed at elucidating problems encountered in the field.

Propagation of citrus varieties on trifoliate stock for experimental purposes has for the present ceased, except for two lines of enquiry, and work is confined to observations on propagations made between 1944 and 1956.

## FIELD OBSERVATIONS

In New South Wales we have been fortunate in that there are considerable numbers of trees on this trifoliate rootstock of mature age (over 25), in most of the citrus-growing areas, both in blocks and as scattered individuals. This is partly due to the early work of Mr. R. J. Benton, Citrus Specialist of the New South Wales Department of Agriculture from 1925 to 1950, who was interested in the beneficial effect this stock had on fruit quality. He had propagated a variety of citrus types on *Poncirus trifoliata*,

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widely distributed in small experimental plantings. It is also partly due to the interest of a former prominent Sydney nurseryman, L. P. Rosen, who propagated and distributed large numbers of trees in the 1920's and 1930's. We have therefore fairly adequate numbers of most of the required commercial varieties of sufficient age for the selection of propagating material for experimental work and for initial observations of symptom variation under field conditions, as well as for the establishment of a bud registration scheme.

**Selection of Promising Scion Material.** The older commercial blocks of trees on trifoliate stock are almost all notable for the variation that is apparent in tree size and type. Surveys have been made with the object of locating outstanding trees free of exocortis virus, and a number of these trees have been selected for trial in experimental orchards at Somersby, Yanco, and Coomealla. They include 24 selections of Valencia orange, 17 of Washington Navel, 6 of Emperor mandarin, and somewhat smaller numbers of other orange, grapefruit, and mandarin varieties. Two of the Valencia and two of the Washington Navel oranges are nucellar selections; the remainder are old-line clones.

A similar program is being carried out by the Victorian Department of Agriculture at Nangiloc and Cobram, using selections of Valencia orange, Washington Navel orange, and to less extent, Marsh grapefruit.

**Insect Transmission.** Testing and selection of exocortis-free lines would be of no value if the virus were readily transmitted by insects. The second line of enquiry based on field observation is therefore the confirmation of the hypothesis that field spread does not readily occur.

During the past 15 years only one case has been located where exocortis has developed in a tree over 10 years old, previously known to be free of the disease. This occurred in a Washington Navel orange tree 24 years old in the orchard of the Hawkesbury Agricultural College, Richmond. This tree, which is one of a number propagated from the same bud source, all well-grown trees with the typical overgrown butt of the virus-free trifoliate stock, started to scale in 1953 in a restricted area on one side, concurrently with some yellowing and leaf fall. After 4 years this tree is now scaling all around the butt, and vigor has declined to such an extent that healthy trees of the same bud line are now noticeably larger. However, this cannot be accepted as proof of insect transmission. Trees in a row adjacent to the affected tree are on Rough lemon stock, and it is not impossible that root grafting occurred and the disease was transmitted from a symptomless tree on Rough lemon stock. If insect transmission occurs, it does not do so frequently enough to jeopardize the use of *Poncirus trifoliata* as a stock.

## EXPERIMENTAL WORK ON EXOCORTIS

Experiments in progress or completed aim: 1) to confirm the virus nature of the disease; 2) to investigate the existence of strains; 3) to elucidate the condition of stunting of trees on *Poncirus trifoliata* unaccompanied by scaling symptoms; 4) to explore possible ways of freeing propagation wood from virus; 5) to test hybrids of *P. trifoliata*; and 6) to investigate the possibility of seed transmission of the virus.

### Confirmation of Virus Nature of the Disease

This part of the investigation is regarded as more or less complete. Buds from trees affected with exocortis reproduce the disease (*a*) when grown as trees on trifoliate seedling stocks, (*b*) when used as inoculating buds worked into virus-free trees, and (*c*) when used as inoculating buds removed after 3 months and worked onto trifoliate seedlings. Trees propagated from exocortis-free sources have proved to be 100 per cent free of this disease.

## Strains of Exocortis

Field observations suggest that exocortis exists in a number of strains. The disease shows the following variations:

1) Development fairly rapid (2 to 4 years from time of budding) and preceded by stunting. Scaling commences at bud union and rapidly involves all the butt to soil level and a little below. Scion and stock diameters much the same.

2) Development slower (6 to 8 years) but of the same general type.

3) Development slow (6 to 8 years). Scaling starts at a point below the bud union and may involve only a relatively small area at first. In the early stages the scales may be exfoliated and the butt may appear to be periodically free of scales, until a more complete scaling becomes established. The stock in this case is moderately overgrown.

4) Another variable is tree size. Small, medium, and fairly large trees are associated with the different types of scaling. Eight of these types have been propagated and planted for comparison of growth rate and type, and scaling type. These experiments are not complete, but observations to date indicate that the budlings reproduce the character of the parent tree without significant variation.

An alternative to the possibility that these variations in symptom type indicate strains of virus could be that they are the result of the effect of virus infection on different strains of the scion. This possibility is being investigated in two ways:

1) Seedlings of *Poncirus trifoliata* were inoculated by budding, and the inoculating bud was removed 6 months after budding. Fourteen sources of exocortis were used.

2) Yearling trees of an exocortis-free line of Valencia orange on *Poncirus trifoliata* were inoculated by budding. Three sources of exocortis types were used.

No results are available so far.

## The Stunting Problem

In addition to the various types of scaling and the various degrees of stunting associated with them, there is a stunting which is not associated with scaling. This has been found to be more pronounced with Washington Navel orange and grapefruit than with Valencia orange and mandarin. In an orchard of Washington Navel oranges grown from unselected buds taken from trees on Rough lemon stock, it is common to find a percentage of trees of excellent growth habit, free of scaling and stunting, a percentage with various types of scaling, and a percentage (usually lower) of stunted trees which do not scale even at an advanced age. This stunting is also somewhat variable, the smallest trees are smaller than the largest scaling trees, and others fall into classes intermediate between these and the largest vigorous trees. This stunting is almost always associated with a certain degree of benching at the bud union.

Trees propagated from stunted parents reproduce the character of the parent tree. The problem is to find out by transmission whether this stunting is viral in nature and, if so, whether it is related to the exocortis disease.

In order to find out whether this condition is due to virus infection, virus-free yearling trees have been inoculated by budding with three selections of stunted scions. Trees used for inoculation were Valencia orange, Marsh grapefruit, and a nucellar Washington Navel selection. These tests have not as yet yielded any results.

The conditions noted in the field could be explained on any of the following hypotheses:

1) That exocortis virus exists in a number of strains varying in the degree of stunting caused and in the amount of scaling—some not causing scaling at all.

2) That stunting and scaling are due to two different viruses, and the variation in symptoms in the field is due to combination of different strains of these two viruses.

3) That stunting is due to the specific type of growth of certain strains of scion on *Poncirus trifoliata* and is not due to virus, and that the variation seen in the field is due to the effect of interaction of exocortis virus and this strain effect.

The demonstration of the virus nature, or otherwise, of stunting is only a matter of time. If stunting proves to be due to a virus, the demonstration of relationship between scaling and stunting may not be possible. Experiments designed to find if there is an interaction have been started. Yearling trees of Marsh grapefruit propagated from scions showing severe, moderate, and no stunting have been inoculated by budding with a severe type of exocortis. In each series half of the inoculating buds have been removed after a period of 6 months. However, information gained from this type of experiment cannot be accepted as conclusive without corroborative evidence.

### Methods of Freeing Propagation Wood from Exocortis Virus

There are a few citrus varieties in New South Wales for which no source of virus-free material is available. Most important of these are the Eureka lemon and the Clementine mandarin. Though it is not a commercial variety here, the only line of Shamouti orange in New South Wales carries a particularly severe type of exocortis. Three methods are being tried.

**Nucellar Seedlings.** Until a few months ago the use of nucellar seedlings appeared to show considerable promise for Eureka lemons. Four nucellar selections of good agronomic type, now 8 years old, have made particularly good growth and have cropped well. The stocks were considerably overgrown, which is regarded as a fairly good early indication of freedom from exocortis. Unfortunately, during the last few months a complicating factor has made its appearance: A number of the trees have developed a ring of gum in the region of the bud union; in some trees it is in the bark only, but in others it is in both bark and wood. The condition is suggestive of the bud-union disorder affecting Eureka lemon on Troyer citrange and *Poncirus trifoliata* recently described by Weathers *et al.* (*7*). The prospects for Eureka lemon on trifoliate stock are therefore not considered to be very bright, even though it appears that exocortis can be eliminated by the use of nucellar material.

**Heat Therapy.** The method of heat therapy used was that devised by Kassanis (*3*) at Cambridge University and used in England with success for treatment of strawberries and raspberries. Citrus trees withstand high temperature treatments very well and make some growth. Buds have been taken from both old and new wood after treatment. No results are as yet available.

**Propagation from Young Growth.** Numbers of propagations have been made with very young growing tips. At a later time it will be determined if virus-free material can be obtained by this method.

### Hybrids of *Poncirus trifoliata* and Other Stocks

Very little attention has been paid to trifoliate hybrids. In the first place few are available to us, and in the second place it is thought unlikely that they would be more valuable under New South Wales conditions than the best selection of *P. trifoliata*. A recent importation of Troyer citrange is being compared with a number of trifoliate stock selections for reaction and growth type when budded with virus-free Washington Navel, Valencia, and grapefruit buds, and with virus-infected buds. The Carrizo citrange is similarly under trial. No scaling has developed in this stock as yet, but trees grown from infected budwood are noticeably weaker at 7 years than exocortis-free trees.

A number of citranges have been raised experimentally and will be tried as rootstocks.

Since the reports by Moreira (*4*), Rossetti (*6*), and Olson and Shull (*5*) of an exocortis-like disease on Rangpur lime, this stock also has been included in trials.

### Experiments on Seed Transmission of Exocortis Virus

All seedling trees of *Poncirus trifoliata* which are used as sources of seed by nurserymen are free of exocortis.

Several exocortis-affected selections at the Narara Citrus Experiment Station regularly produce fruit, and 1200 seedlings raised from these have been planted for observation on possible seed transmission. The oldest of these are now 8 years old, but no symptoms are as yet apparent.

## CONCLUSIONS

Although much of the experimental study outlined above is as yet incomplete, present information concerning the exocortis disease permits the following generalizations:

1) Exocortis is caused by a virus.

2) The virus is apparently not seed-transmitted in significant amounts.

3) Infection and development of symptoms on citrus trees growing on trifoliate orange and other susceptible rootstocks result chiefly from the use of scion buds from exocortis-infected sources.

4) The urgent need is for a seedling indicator which will show symptoms within a few months of inoculation. So far, the search for such a variety has been unsuccessful. The use of *Poncirus trifoliata* itself as a test plant involves not only a long delay before results can be obtained, but also the necessity for a large area of land for growing trees and a greater amount of labor for their maintenance. This lack has considerably restricted experimental work.

## LITERATURE CITED


1. Benton, R. J., F. T. Bowman, Lilian Fraser, and R. G. Kebby. Selection of citrus budwood to control scaly butt in trifoliata rootstock. Agr. Gaz. N. S. Wales **60:** 31–34. 1949.
2. Benton, R. J., F. T. Bowman, Lilian Fraser, and R. G. Kebby. Stunting and scaly butt of citrus associated with *Poncirus trifoliata* rootstock. N. S. Wales, Dept. Agr., Sci. Bull. **70:** 1–20. 1950.
3. Kassanis, B. Heat-therapy of virus-infected plants. Ann. Appl. Biol. **41:** 470–474. 1954.
4. Moreira, S. A moléstia "exocortis" e o cavalo de limoeiro cravo. Rev. Agr. (Piracicaba) **30:** 99–112. 1955.
5. Olson, E. O., and A. V. Shull. Exocortis and xyloporosis—bud-transmission virus diseases of Rangpur and other mandarin-lime rootstocks. Plant Disease Reptr. **40:** 939–946. 1956.
6. Rossetti, Victoria. A doença do limoeiro cravo nos laranjais de São Paulo. [A disease of Rangpur lime in São Paulo citrus plantations.] O Biologico **21:** 1–8. 1955.
7. Weathers, L. G., E. C. Calavan, J. M. Wallace, and D. W. Christiansen. Troyer citrange with Eureka tops. California Citrograph **40:** 427. 1955.