EXOCORTIS IN FLORIDA[1]

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INTRODUCTION

The Florida State Plant Board established its Tristeza Laboratory in Argentina in 1948. The primary purpose of the Laboratory was to afford Florida pathologists the opportunity of becoming familiar with tristeza, but secondary benefits proved to be quite as valuable. The tours of duty of the various pathologists made it possible to develop a familiarity with diseases that at the time were not known in Florida. Among these diseases were cancrosis B (*9*), Tryon's scab (*14*), sweet orange scab, Oberholzer's stem pitting (*16*), xyloporosis (*15*), and exocortis (*17*). As personnel of the Argentine Laboratory returned to the United States, they recognized some of these diseases, previously overlooked in Florida. Thus xyloporosis was detected in Florida in 1951 (*10*) and exocortis in 1954 (*18*).

HISTORY

In 1948, Fawcett and Klotz (*11*) published the original description of exocortis and mentioned its occurrence in California. In 1949 and 1950, Benton *et al.* (*1, 2*) reported on studies of exocortis (scaly butt) in Australia, which they began in 1943. In 1950, McClean (*19*) mentioned its existence in South Africa, and in 1951, Knorr, DuCharme, and Banfi (*17*) reported its presence in Argentina.

Though exocortis was not described and named until about ten years ago, its existence as far back as the early 1920's can be deduced from the literature (*13, 22*). In 1915, Coit (*7*) stated that in California trifoliate orange as a rootstock was "very objectionable for lemon and an absolute failure in every case recorded" in the State. Davis (*8*), in 1924, mentioned severe dwarfing as occurring in South Africa among "every kind of lemon and grapefruit and practically all sweet orange scions" when grafted on trifoliate orange.

The status of exocortis in Florida immediately prior to 1954 was that of a disease whose presence in the State was only strongly suspected. Trifoliate orange came into general use in northern Florida around 1895 (*12*). In 1899, H. H. Hume began testing it as an alternative rootstock for sweet and sour orange, and compared these three varieties as stocks for 23 different varieties of sweet orange, mandarin, and grapefruit. At the end of the first three years' growth in the grove, Dr. Hume's comment regarding trees on trifoliate orange was as follows: "Strange to say, not a single case has come under observation where the stock did not outgrow any variety worked on it." These trees remained in good condition, without showing exocortis, until they were killed in the freeze of 1906 (H. H. Hume, in personal communication dated November 4, 1957). Since these combinations reached the age of six or seven years, they were old enough to have shown conspicuously some of the symptoms of exocortis—stunting, scaling, or failure to develop overgrowths of the stock. Failure to mention any of these symptoms suggests that exocortis virus was not widespread at the turn of the century. Certain it is

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that today one would expect to encounter exocortis in many of 23 different varieties budded on trifoliate orange.

The length of time that exocortis has been in Florida might be gauged by the oldest trees known to show this disease in the State. Thus far, we have found exocortis in a tree at Boardman that was budded and planted prior to the freeze of 1894–95. Such a gauge, however, yields only minimum figures. Undoubtedly, any older trees showing exocortis might well have been pulled earlier.

Although the incidence of exocortis has never been conspicuous in Florida groves, it has shown up in other parts of the world in trees budded with wood from Florida sources. Thus, in Louisiana, trifoliate orange seedlings budded with citrus material from Florida have been known to develop exocortis. A similar case was observed by the senior author at Salto, Uruguay. Señor Pedro Solari, that nation's leading citrus grower, on one of his trips to Florida, selected budwood of four varieties of grapefruit, namely, Duncan, Thompson, Foster, and Marsh Seedless, to take back to Uruguay. According to him all four selections were budded to a single lot of trifoliate orange seedlings. Twenty years later, when seen by the writer, all trees of Thompson, Foster, and Marsh Seedless were healthy and normal in size for their age. The Duncan trees, however (approximately 100 of them), all showed severe stunting and scaling at the trifoliate orange butts.

IMPORTANCE OF EXOCORTIS IN FLORIDA

Exocortis is one of the least frequently encountered diseases in Florida. This statement, however, is less a commentary on the existence of exocortis virus than it is on the sparsity of susceptible rootstocks in the State. Trifoliate orange has never been one of the major rootstocks in Florida, and its use currently, as well as in the past, has been mostly as a stock for Satsuma mandarin. Since Satsumas are grown primarily in the northern part of the State, well removed from the heart of the orange, grapefruit, and tangerine belt, there may have been few occasions to try trifoliate orange for varieties other than Satsumas. There is also the likelihood—though the literature is singularly silent on the subject—that trifoliate orange might have been tried from time to time in central Florida, but that due to exocortis, its performance was continually disappointing and its use therefore abandoned.

According to current figures on the movement of nursery stocks in Florida, trifoliate orange is used as a rootstock for only 2 per cent of the annual propagations (*25*). Most of the 35,000 trees budded each year to trifoliate orange are Satsumas. The few sweet oranges, grapefruits, and mandarins propagated on this stock are planted in dooryards and are thus mostly lost to citrus-tree enumerators and pathologists.

Though rarely encountered in central Florida, trifoliate orange comes into its own in the Satsuma-growing belt of the Gulf States, where nearly all citrus trees are on this rootstock. The virtues of trifoliate orange, as pointed out long ago by Hume (*12*), are that it 1) resists foot rot, 2) induces resistance to cold in the tops, and 3) produces fruits of high internal quality.

Several different surveys have been conducted in these Satsuma groves, and exocortis-like scaling has been conspicuously absent. The trees are small in comparison with trees of the same age in central Florida, but this retarded growth may well be due to shorter growing seasons and frequent freezes rather than to stunting effects of exocortis. So far, indexing has not been carried out to determine whether exocortis virus is present in these trees. It remains to be learned 1) whether Satsumas on trifoliate orange are tolerant of exocortis virus, 2) whether Satsumas have escaped becoming infected, or 3) whether climatic factors interfere with normal development of symptoms where this combination is customarily grown. It is of interest to note that exocortis has not yet been described from Japan, where most of the 30 million citrus trees are on trifoliate orange, and where the main top variety is Satsuma. To what extent the Japanese disease "Satsuma dwarf" may be due to stunting effects attributed to exocortis remains to be investigated.

Rootstocks Susceptible to Exocortis. Trifoliate orange was the first rootstock on which exocortis was observed in Florida. Subsequently, the disease was also encountered in various citranges including Rusk, FCES selections 0–2, 0–11, and 0–12, and in a citrangeuma.

Recently, we found Rangpur lime disease developing concurrently with exocortis in Florida. Presence of Rangpur lime disease was discovered in a rootstock trial set out in December 1950. Two scion varieties were represented in this trial: the Henninger strain of Ruby Red grapefruit and Valencia sweet orange. Budwood came from two 19-year-old Ruby Red trees and from two 26-year-old Valencia trees, all four on Rough lemon rootstocks. All parent trees appeared healthy at time of collection of budwood. However, from what is known now, at least one of the parent Valencia trees and both of the grapefruit trees were infected with exocortis virus at the time budwood was collected.

Rootstock varieties included in this test were Rough lemon, sweet orange, sour orange, Cleopatra mandarin, Sampson tangelo, trifoliate orange, and Rangpur lime.

Trees were planted according to an experimental design consisting of 7 × 7 Latin squares with 2-tree plots. Measurement of growth rates began 3½ years after budding. Figure 1 shows that least increase in trunk circumference was made by the trees on trifoliate orange rootstock. The performance of Rangpur lime, on the other hand, placed it among the three most vigorous rootstocks, along with sweet orange and Rough lemon. If it had not been for the fact that 20 to 35 per cent of the trees showed Rangpur lime disease, it is probable that Rangpur lime would have proved itself the most vigorous stock in the experiment.

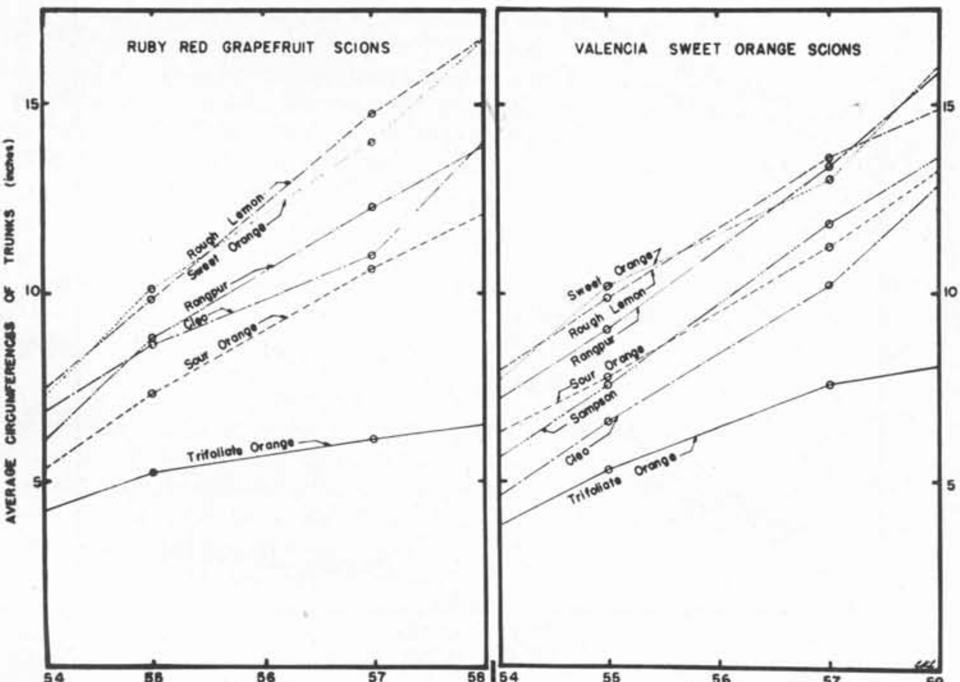

Fig. 1. Growth rates of Ruby Red grapefruit and Valencia orange trees budded on various rootstocks in May 1950 and planted in Leon soil, Fort Pierce, Florida.

Scaling of the exocortis type appeared in two of the stocks, trifoliate orange and Rangpur lime. Figure 2 shows the rate of scaling in these stocks.

From the data presented in these two figures, we have derived the following conclusions, some of which confirm those previously announced by Moreira (*20*) and by Olson and Shull (*21*):

1) The trouble causing stunting and scaling of Rangpur lime stocks resembles in appearance and behavior the Rangpur lime disease described from Brazil (*20*) and from Texas (*21*).

2) The virus responsible for Rangpur lime disease in Florida is either the same as that causing exocortis in trifoliate orange or very closely associated with the latter.

3) A retardation in rate of growth is the first symptom observed in affected Rangpur limes. Stunting becomes evident in from 4 to 5 years after budding. Scaling of the bark appears a year or more later. The interval between budding and first appearance of scaling is approximately the same as that reported from Brazil and Texas. The relatively short incubation period, however, is in contrast to the situation in California alluded to by Calavan *et al.* (*6*) in which rootstock experiments up to 7 years of age did not show a relationship between presence of exocortis in trifoliate orange on the one hand, and scaling in Rangpur lime on the other.

4) Budwood containing exocortis virus causes early and severe stunting of all trees on trifoliate orange. The same budwood, however, when inserted in Rangpur lime, causes stunting in only a small percentage of trees. Also, the degree of stunting is much less than that in trifoliate-orange-rooted trees, and its first appearance occurs

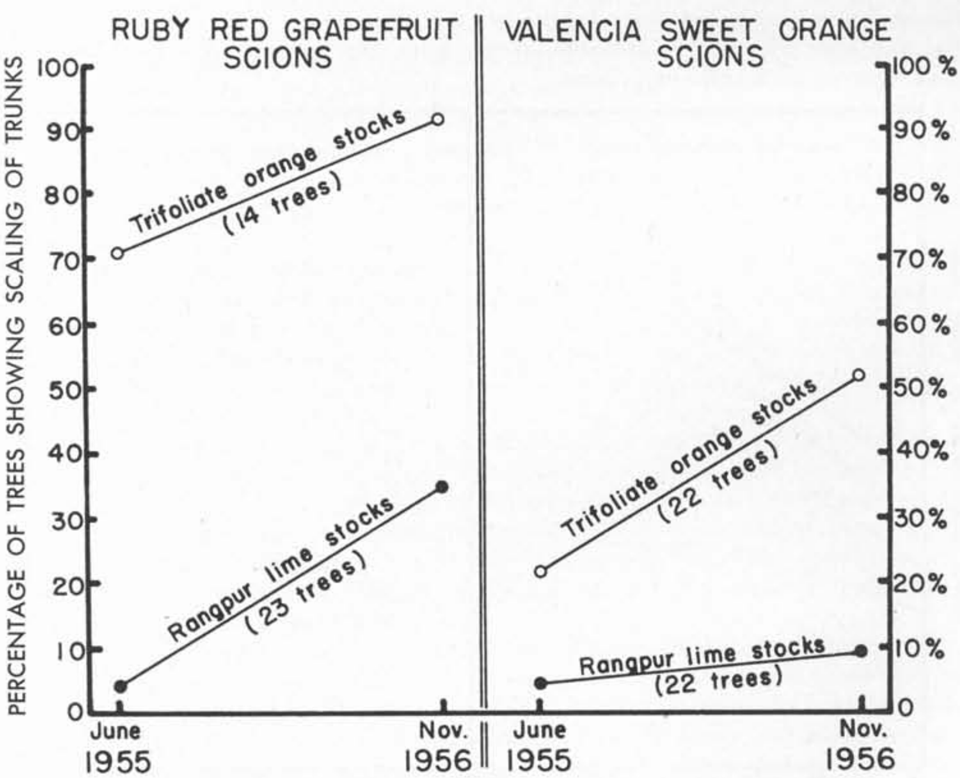

Fig. 2. Percentage of trees of grapefruit and Valencia orange showing scaling on rootstocks (trifoliate orange and Rangpur lime) at 5 years from budding and increase during the following 16 months at Fort Pierce, Florida.

Table 1. CITRUS VARIETIES IN CERTAIN CLONES OF WHICH THE VIRUS EXOCORTIS HAS BEEN REPORTED

Variety	Location, reference, and incidence*
Sweet orange:	
Argel	Argentina *(17)*
Argentine Common ("Comun")	Argentina *(17)*
Argentine Common Blood	Argentina *(17)*
Australian Navel	Australia *(2)*[4]
Azucarada de los Azores	Argentina *(17)*
Bahianinha	Brazil *(20, 24)*
China de Cascara Delgada Lisa	Argentina *(17)*
Del Cielo	Argentina *(17)*
Hamlin	Brazil *(20, 24)*, Florida
Jaffa	Argentina *(17)*, Texas *(21)*
Laranja Cravo	Brazil *(24)*[4]
Lue Gim Gong	Argentina *(17)*
Maracana	Brazil *(20)*
Mediterranean Sweet	Florida
Pera	Brazil *(24)*
Pineapple	Argentina *(17)*
Piralima	Brazil *(24)*
Ruby Blood	Argentina *(17)*
St. Michael	Australia *(2)*
Thompson Navel	Australia *(2)*[1-4]
Valencia	Australia *(3)*[4], California *(11)*, Florida *(23)*, Texas *(21)*[4]
Washington Navel	Australia *(3)*[2-3] South Africa *(19)*[4]
Mandarin:	
Argentine Common ("Comun")	Argentina *(17)*
Campeona	Argentina *(17)*
Clementine	Australia *(2)*[2]
Cutro	Argentina *(17)*
Ellendale	Australia *(2)*[4]
Emperor	Australia *(2)*[4]
Temple	Florida
Thorny	Australia *(2)*[2]
Mandarin—*continued*	
Unshiu	Australia *(2)*[4]
Unspecified varieties	Australia *(3)*[4]
Grapefruit:	
Duncan	Argentina *(17)*, Florida
Florida	Argentina *(17)*
Marsh Seedless	Argentina *(17)*, Australia *(3)*[4], Brazil *(20)*, Florida
Pernambuco	Argentina *(17)*
Ruby Red	Florida *(23)*, Texas *(21)*[2]
Thompson	Argentina *(17)*, Australia *(3)*[2-3]
Triumph	Argentina *(17)*
Wheeny	Australia *(2)*[4]
Unspecified varieties	South Africa *(19)*[4], California *(11)*
Kumquat:	
Nagami	Argentina *(17)*, Florida
Lemon:	
English	Argentina *(17)*
Eureka	Australia *(3)*[1], California *(5)*
Lisbon	Australia *(3)*[1]
Lumma	Argentina *(17)*
Unspecified varieties	Florida
Lime:	
Key	Argentina *(17)*
Sweet lime	Brazil *(24)*[4]
Shaddock:	
Unspecified variety	Florida
Tangelo:	
Orlando	Florida
Unspecified variety	Florida

* Incidence values expressed by superscript numerals: [1] nearly 100 per cent, [2] high, [3] moderate, [4] low.
It is generally understood that statements regarding incidence apply only to clones under observation or test, and not necessarily to varieties as a whole.

Table 2. CITRUS ROOTSTOCKS REPORTED AS SHOWING SYMPTOMS OF EXOCORTIS

Variety	Location and reference	Degree of susceptibility reported
Trifoliate orange	Argentine (*17*)	..
	Australia (*2*)	..
	Brazil (*20, 24*)	..
	South Africa (*19*)	..
	California (*5, 11*)	Maximum
	Florida (*18*)	..
	Texas (*21*)	..
Citrange:		
Cunningham	California (*4*)	..
Morton	California (*5*)	Moderate
	Texas (*21*)	..
Rusk	Florida	..
Troyer	California (*5*)	Slight
Mandarin-lime:		
Kusaie	Texas (*21*)	..
Ling Mung	Texas (*21*)	..
CPB #7418	Texas (*21*)	..
CPB #10557	Texas (*21*)	..
CPB #72901	Texas (*21*)	..
Paak Ling Mung	Texas (*21*)	..
Rangpur	Brazil (*20, 24*)	..
	Florida (*23*)	..
	Texas (*21*)	..

later than it does in trees on trifoliate orange. This delay and lack of uniform reaction in Rangpur lime stocks may be the result of one or a combination of several possibilities: the incubation period of the virus in Rangpur lime may be longer than in trifoliate orange, or Rangpur lime may possess a lower nucellar rate, as a consequence of which there might be greater variability in the susceptibility of Rangpur lime seedlings. Design of this experiment does not shed light on which of these explanations, if either, is the proper one.

5) Rootstocks that are tolerant of exocortis virus are Rough lemon, sweet orange, sour orange, Cleopatra mandarin, and Sampson tangelo. None of these is yet (after 7½ years) affected by bark scaling or by any conspicuous stunting.

6) Symptoms in this experiment are not confounded by tristeza virus. Tristeza was judged to be absent because of the normal development of all trees on sour orange rootstocks. Nothing is known, however, as to whether the virus of xyloporosis was present or absent.

Scion Varieties Infected with Exocortis Virus. As mentioned, exocortis is seldom seen in Florida. The disease, however, is encountered wherever rootstock trials include such varieties as trifoliate orange, various citranges, and Rangpur lime. It begins to appear that exocortis virus, like the virus of xyloporosis, may be widespread among tolerant varieties, xyloporosis virus having recently been reported to be present in 63 per cent of 339 trees (30 varieties) tested. To date, our observations of trees on trifoliate orange, both in commercial groves and in rootstock experiments, show that exocortis virus exists in certain clones of sweet orange (Valencia, Mediterranean Sweet, Hamlin), grapefruit (Ruby Red, Duncan, Triumph), Temple orange, and among some shaddocks, kumquats, tangelos, and lemons.

Elsewhere in the world, other varieties are mentioned as being carriers of exocortis virus. Reports dealing with the distribution of exocortis, as summarized in tables 1 and 2, show that exocortis virus must be widespread in commercial citrus varieties and that few if any varieties have escaped infection or are immune.

Instances of False Exocortis in Florida. In Florida certain field symptoms occur that could lead to erroneous diagnoses of exocortis. Scaling confusingly similar to that caused by the exocortis virus has been observed on stocks not related to trifoliate orange. Confusion is compounded by the fact that such unrelated stocks may, as in the case of healthy trifoliate orange rootstocks, develop overgrowths of the butts below the bud union. One rootstock known to produce butts resembling those of trifoliate orange and to develop scaling resembling exocortis in Florida Everbearing lemon (fig. 3). Whether scaling in this variety signifies that Florida Everbearing lemon is another suscept of exocortis, or whether it is an instance of false exocortis scaling (due perhaps to some trouble such as shell bark or dry bark) remains to be investigated.

Another set of symptoms confusable with exocortis is a beaded type of eruption occasionally seen here on trifoliate butts (fig. 4). The eruptions consist of patches of laminated bark varying in width from $\frac{1}{4}$ to 1 or 2 inches. These areas occur as arcs $\frac{1}{2}$ to 5 inches long curving around the trifoliate-orange portion of the trunk. The

Fig. 3. Butts resembling those formed by trifoliate orange may be produced by certain other varieties of citrus. Pictured here is a sweet orange tree on Florida Everbearing lemon rootstock. Swelling of the butt and the accompanying scaling may lead to confusion in the diagnosis of exocortis, as well as to the improper identification of the rootstock.

laminated appearance of the bark suggests that the abnormality might be genetic, possibly an atavism or reversion to the bark condition that is common in such rutaceous relatives as *Hesperethusa* and *Zanthoxylum*. The fact that trees with laminate shelling are usually not stunted—though some of them may be as much as 30 years old—suggests that these eruptions do not indicate the presence of exocortis virus.

A third condition occasionally found in Florida groves, which might be confused with exocortis, is a trouble we call "podagra." This abnormality affects kumquat trees, both Meiwas and Nagamis, on Rough lemon stocks. "Podagra" is suggestive of a virus disease in that its distribution in blocks of kumquat trees is spotty, as if rootstocks had been budded with different clones, some of which contained a factor for this abnormality and some not. Symptoms consist of a marked overgrowth of the Rough lemon rootstock and a scaling of the bark (fig. 5). Taken together these symptoms suggest that affected trees are on trifoliate orange stocks and that scaling is due to exocortis. The impression of exocortis is increased by the depauperate appearance of the tops of such trees.

The three above-mentioned cases of false exocortis are all distinguishable from true

Fig. 4. Laminate shelling, a type of bark eruption seen occasionally on trifoliate orange rootstocks. While resembling scaling due to exocortis, it is not associated with any stunting of the tree; therefore, this symptom is assumed not to indicate the presence of exocortis virus.

exocortis by overgrowth of the rootstocks. As pointed out originally by Benton *et al.* (*2*), the development of a marked shoulder in trifoliate orange is generally suppressed when trees on this rootstock are infected with the exocortis virus.

CONCLUSION

Although exocortis does not at present loom large in Florida's citrus economy, it does represent an indirect source of loss, because it prevents use of a potentially valuable, much-needed rootstock. With Florida's sour orange acreage (about 15 per cent of the total) in jeopardy because of tristeza, there is great demand for stocks that will tolerate tristeza virus and yet grow satisfactorily in the heavy, wet soils of the State's coastal areas. Because of its resistance to foot rot and tolerance to tristeza and cold, and because of its production of fruit with high solids, trifoliate orange is a logical replacement for sour orange. It is hoped that the Florida Budwood Certification Program with its objective of finding varieties free of exocortis virus, or that the use of nucellar budwood, will some day turn this valuable rootstock to the State's account.

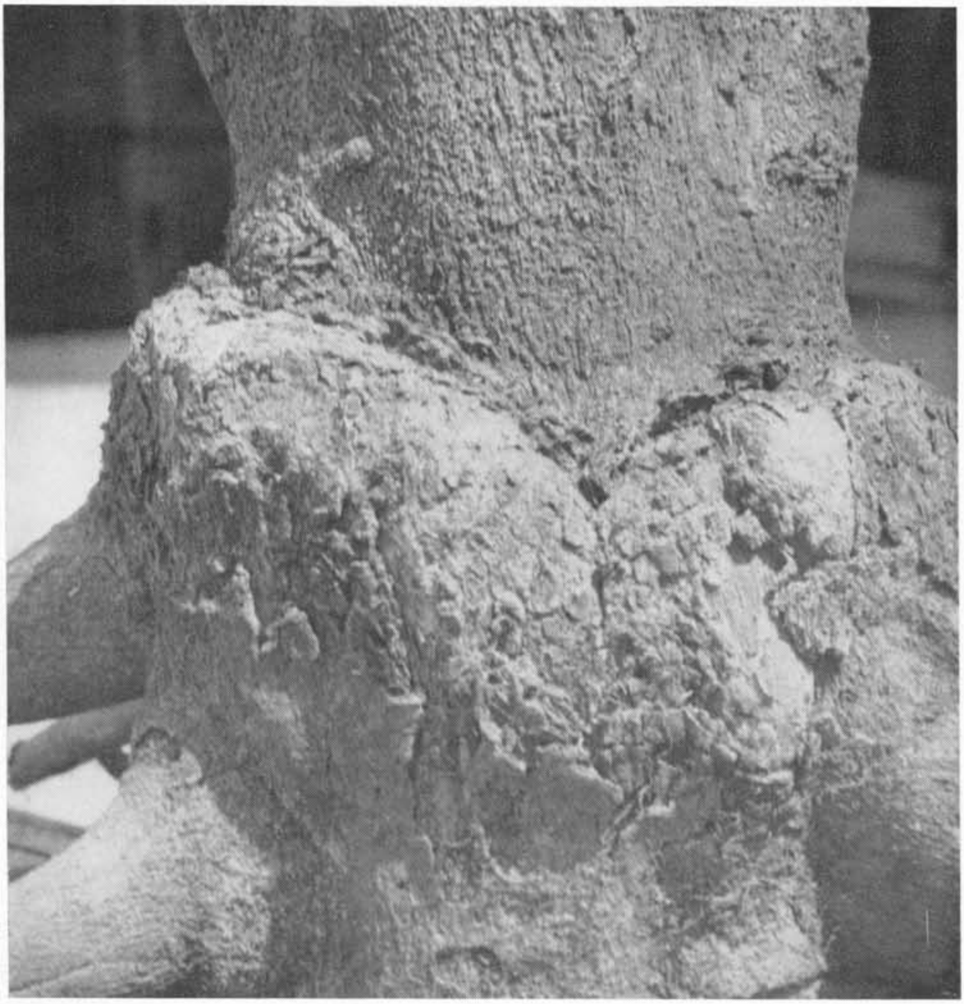

Fig. 5. "Podagra," a disease of kumquat trees on Rough lemon rootstocks, the symptoms of which suggest that affected trees are on trifoliate orange stocks and that the butts are scaling because of exocortis.

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