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FIRST STUDIES ON THE STUBBORN DISEASE OF CITRUS IN SOME MEDITERRANEAN COUNTRIES

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INTRODUCTION

Before discussing the work we have done on the stubborn disease in Morocco and other Mediterranean countries, we take this opportunity to express our best thanks to Dr. L. J. Klotz of the University of California Citrus Experiment Station, Riverside, and to Dr. J. F. L. Childs of the U. S. Horticultural Field Station, Orlando, Florida. Dr. Klotz first visited Morocco in May 1953, and then again in May to June 1957. Dr. Childs came to Morocco in May 1955. Their stay in Morocco, the discussions we had with them, and the letters they wrote us have helped us a great deal in the study of this disease, which has been recognized for only a few years in this part of the world.

In November 1949, a citrus grower in Morocco brought to the attention of the Horticultural Research Department the fact that some Washington Navel orange trees had a tendency to produce blossoms all the year through. The fruits were distorted, had a thick, rough peel, and were of no commercial value. Furthermore, the sickest trees had more or less the shape of an oblate spheroid.

The condition of the trees was attributed at that time to a bad choice of budwood. It appeared that the budwood of these trees might have come from a clone similar to the one called "Australian" in the United States, which produces an undesirable type of tree. Consequently, growers were advised to top-work the trees and propagate with budwood taken from normally growing trees.

In November 1951, the same citrus grower reported that the symptoms had shown up on other trees, especially on some 26-year-old orange trees of the local "Blida" variety. As to the trees which had first shown the trouble in 1949, the symptoms were now much more pronounced and had apparently spread to adjacent trees. These observations were immediately checked and shown to be right.

A field survey was then made in that area and in other districts of Morocco and it was found that the disease was present in various degrees in all of the groves examined. Since that time, we have detected it in other countries of the Mediterranean area, namely, in Algeria (1952); Tunisia (1953); Lebanon, Syria, and Turkey (1956); and Corsica (1957).

We have some reasons to believe that the disease exists in Spain, also, where the sick trees are called "lazy" trees. We do not have much information on Italy, but we know that a certain orange variety from Sicily, called "Ovale Calabrese" (*1*), shows symptoms much like those of stubborn disease, not only in Sicily, but also in Morocco, Algeria, and Turkey.

As to Egypt, Childs, Nour-Eldin, and El-Hosseiny (*3*) have reported the interesting case of an orange variety, Safargali, which is considered as a degenerated clone in

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Egypt but which is more likely a pathological condition resulting from what we think is the stubborn disease.

In Israel, Reichert (7) has found some fruit distortions (lopsided fruits) which are very similar to the ones we have observed in other countries of the Mediterranean area, and which he believes to be due to xyloporosis. However, we think that in Israel the stubborn disease may be the cause of these abnormal fruits. Furthermore, in Lebanon, Syria, and Turkey, we had the opportunity to see trees which had been recently introduced from Israel, and which showed all the symptoms of stubborn, especially the acorn-shaped fruit (2).

So we have the strong feeling that all the countries of the Mediterranean area have the stubborn disease or at least that they have the same disease as the one we have studied in Morocco, the symptoms of which we will now describe.

SYMPTOMATOLOGY

Fruit. The fruit on affected trees may show two main types of deformation: 1) that described as acorn fruit (*4, 5, 6*), as shown in figure 1, and 2) that described as lopsided fruit (*7*). Sometimes fruit of the former type is not typically acorn-shaped but cylinder-shaped (an early stage of acorn fruit). In Morocco, these acorn- and cylinder-shaped fruits have been seen on many orange varieties, but never on grapefruit or mandarin. Lopsided fruit is caused by a curvature of the fruit axis (columella). Interestingly enough, these lopsided fruits appear on trees which produce also acorn fruit. Cylindrical, slightly acorn-shaped, and lopsided fruits found on three varieties of sweet orange are shown in figure 2.

Besides deformation, the fruits on affected trees may show other symptoms: 1) On navel oranges (Washington, Thomson, and Robertson), one notices a complete closing of the umbilicus. The surface of the fruit around the closed umbilicus becomes concave,

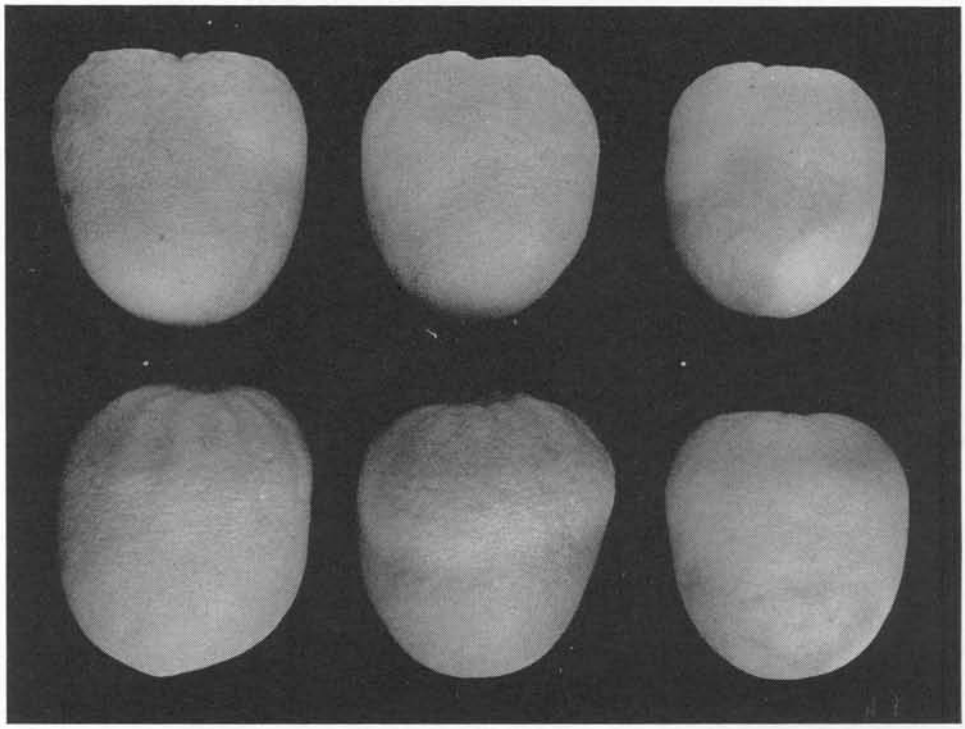

Fig. 1. Acorn-shaped fruits from stubborn-disease-affected tree of blood orange (Grosse Sanguine).

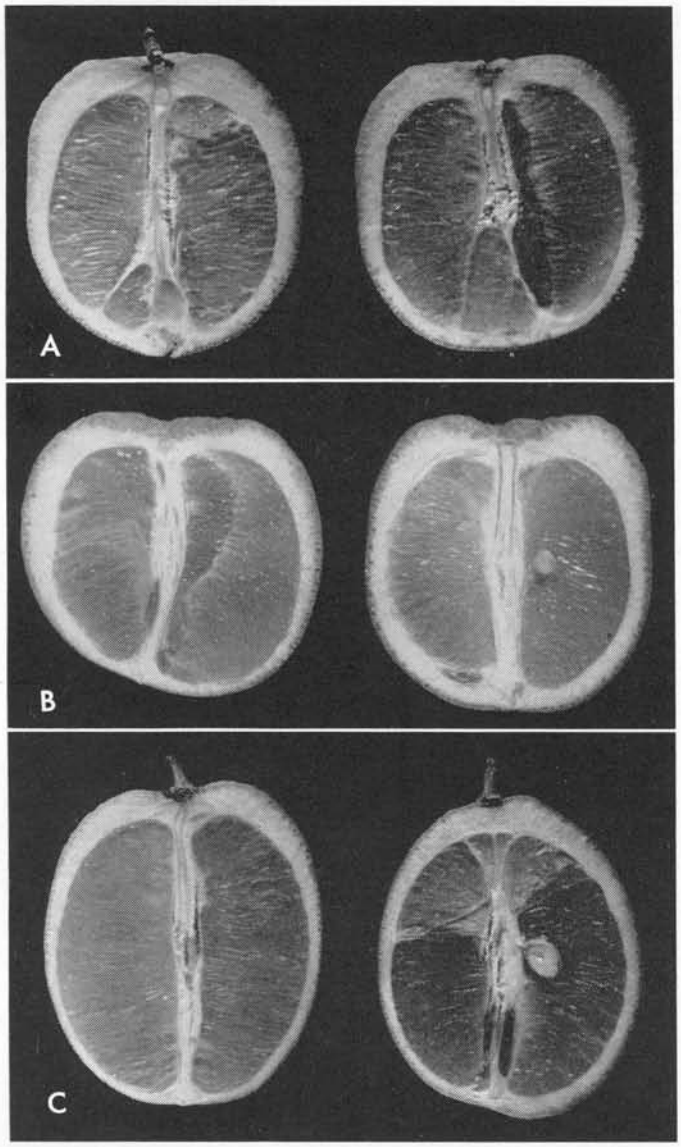

Fig. 2. Half-sections of fruits picked from trees of three different sweet orange varieties in Morocco: A) cylindrical fruits of Washington Navel showing slight acorn shape; B) cylindrical fruits of an unidentified, round-fruited Florida variety (section on the left shows a curving of the columella); C) fruits of Verna orange which normally produces egg-shaped fruit. Left, a cylindrical fruit; right, an egg-shaped, lopsided fruit.

whereas this area on normal fruits is more or less convex. 2) The fruit peel is modified, especially where the rind is thinnest, the essential oil glands becoming smooth and having a decreased oil content (*8*). 3) There are also changes in the ripening of the fruit. On healthy fruit, the orange color appears first at the distal (stylar scar) end and then progresses in the direction of the proximal (calyx) end. On affected fruit, it is exactly the reverse that takes place, the distal end remaining green much longer than the proximal. 4) The differences between the two halves of the fruit also show

up in the composition of the fruit juice of Washington Navel and Valencia oranges, as with Rangpur lime (*8*). 5) The general color of the fruit also is changed, the affected fruits having a more yellowish color and remaining greenish for a long time.

Lopsided fruits found on trees of other varieties may have either straight or curved columella, and on the underdeveloped portion of the fruit the peel is very thin. These symptoms are shown on fruits of Clementine mandarin and Rangpur lime in figure 3.

Finally, one should mention that especially on the acorn-shaped fruits a secondary rot is often growing at that very place where the peel is the thinnest. Externally, this rot looks very much like *Pseudomonas syringae* (*Bacterium citriputeolens*) on Bergamot oranges in certain Mediterranean countries.

Flowering Schedule. Whereas the blooming time of a healthy tree takes place in March, April, and May, that of a diseased tree starts much sooner and keeps on much longer. There is a second blooming period from September to January, with maximum bloom in October to November. Thus one gets the impression that the affected tree is everbearing (fig. 4). Unfortunately, the fruits of this off-bloom tree do not have any juice and hence are of no commercial value.

Leaves and Shoots. On the affected trees, one can notice two types of leaves: 1) those normal in shape but very small, and 2) those abnormally shaped (fig. 5). The small-sized leaves, which in size and shape resemble leaves of tangelo, are pro-

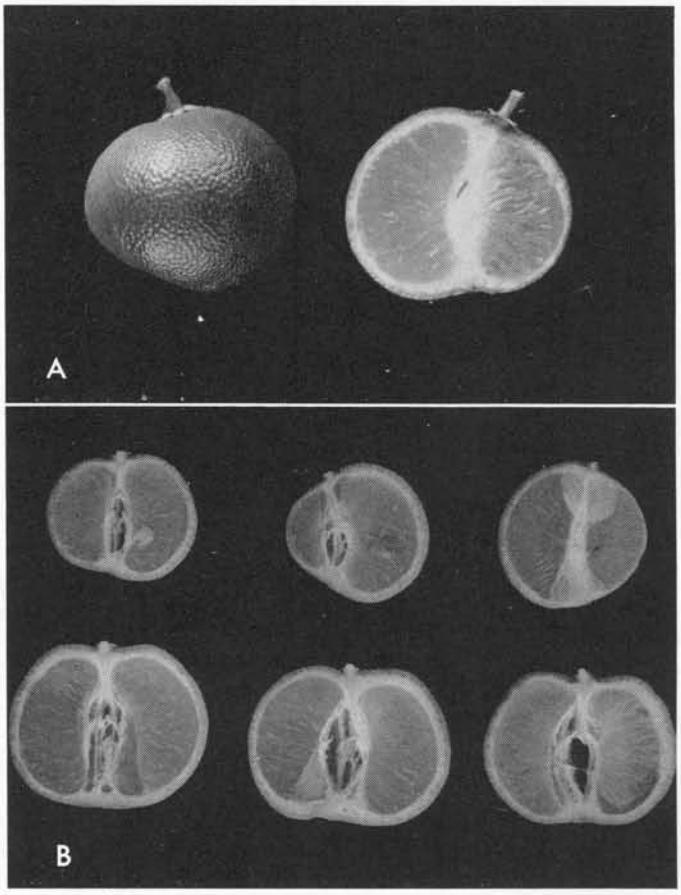

Fig. 3. Lopsided and normal citrus fruits: A) fruits of Clementine mandarin; B) upper row, half-sections of lopsided fruits of Rangpur lime; lower row, half-sections of normal fruits of Rangpur lime.

Fig. 4. Mature fruits, small green fruits, and flowers present simultaneously on a stubborn-disease-affected Washington Navel orange tree in Morocco.

duced on the short, bushy shoots that develop from multiple buds (fig. 6). The tangelo-type leaves grow in one single plane on S-shaped shoots instead of on the normal straight ones. These S-shaped twigs are especially visible at the periphery of the tree.

On a healthy tree, the buds located at the base of a one-year-old shoot do not grow out normally into twigs. On a diseased tree, however, these buds start growing and produce short, slender shoots, thus giving the branches a bushlike appearance. The combined effects of these various symptoms—modification of the leaf shape and size, special insertion of the leaves on the shoots, growth of multiple buds, and shortening of the internodes—change the over-all shape of the tree (fig. 7). The more pronounced the symptoms are and the sooner the infection takes place, the flatter the tree gets. With severe infection, the result is a dwarfed tree because of the absence of new shoots and suckers.

EVOLUTION

We have never observed a tree that has been killed by the stubborn disease. Apparently, most of the affected trees reach a stage of equilibrium. Growth almost ceases and the tops of the trees flatten. Blossoms may appear throughout the year, but the trees bear poor-quality fruits and little by little the fruits become fewer.

It has never been possible to see an evolution the other way around, from a diseased tree to a normal tree. Sometimes a drastic pruning is followed by the development of new shoots, with normal-shaped, normal-sized leaves, but after one or two years, the tree reverts to its diseased appearance.

TRANSMISSIBILITY

It is possible to transmit the disease by grafting with budwood taken from affected trees. Likewise, the growth from healthy buds put into a diseased tree shows symptoms of the disease. It is not known if the disease has an insect vector; however, the rather

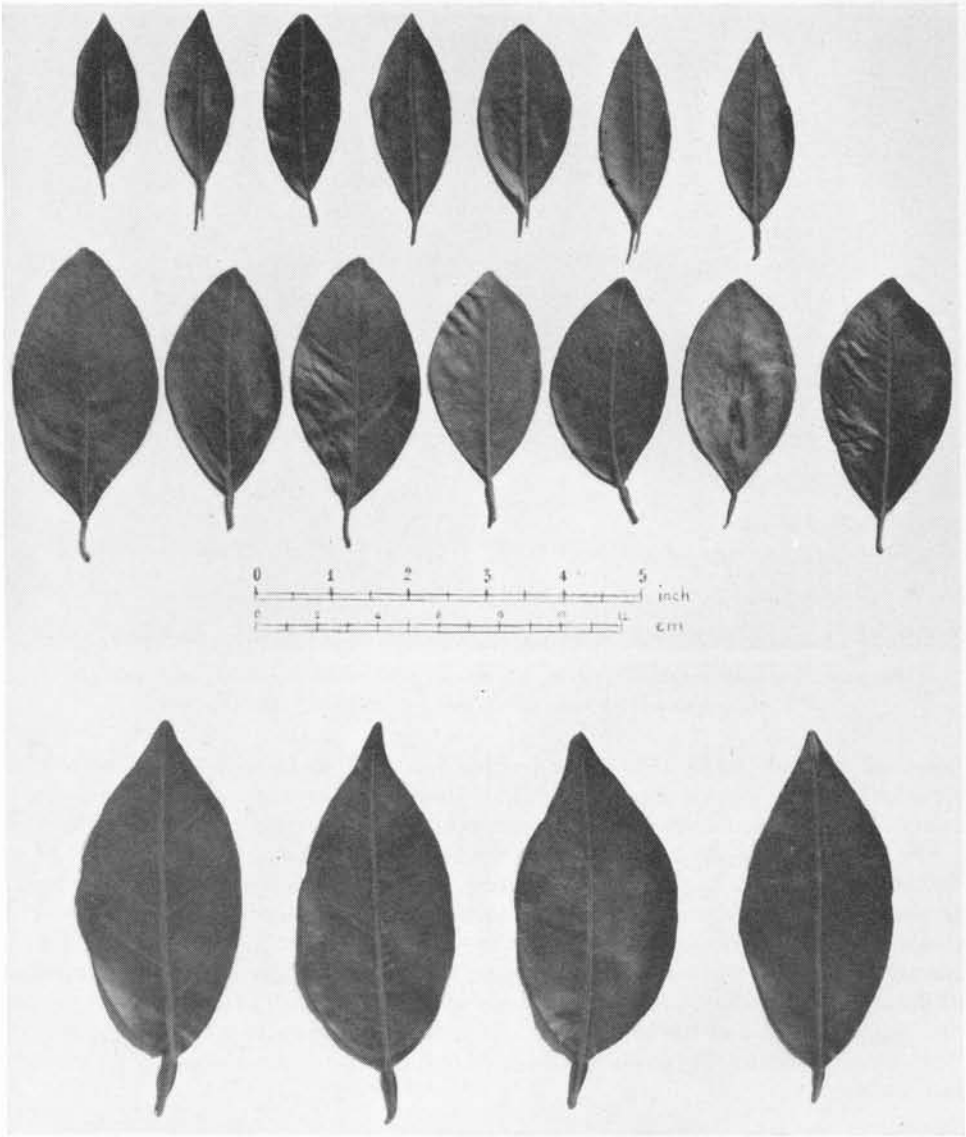

Fig. 5. Effect of stubborn disease on size and shape of leaves of Grosse Sanguine orange. Bottom row, normal leaves from healthy tree. Center row, "tangelo-type" leaves from stubborn-disease-affected tree. Top row, dwarfed leaves from stubborn-disease-affected tree.

sudden appearance of the disease in very old, vigorous trees indicates that an insect vector may be involved.

CITRUS SPECIES AND VARIETIES SUBJECT TO STUBBORN DISEASE

We have never found the disease on lemon, *Citrus limon* (Linn.) Burm. The same is true for citron, *C. medica* Linn., although we do see some distorted fruits on this species. The presence of distorted fruits is very common, however, and not believed to be pathological. We could not detect the symptoms on West-Indian-like limes, *C. aurantifolia* (Christm.) Swing. It seems, however, that other limes (or lime hybrids) such as Rangpur could carry the disease.

Fig. 6. Small leaves and bushy twig growth on tree of Washington Navel orange affected by stubborn disease.

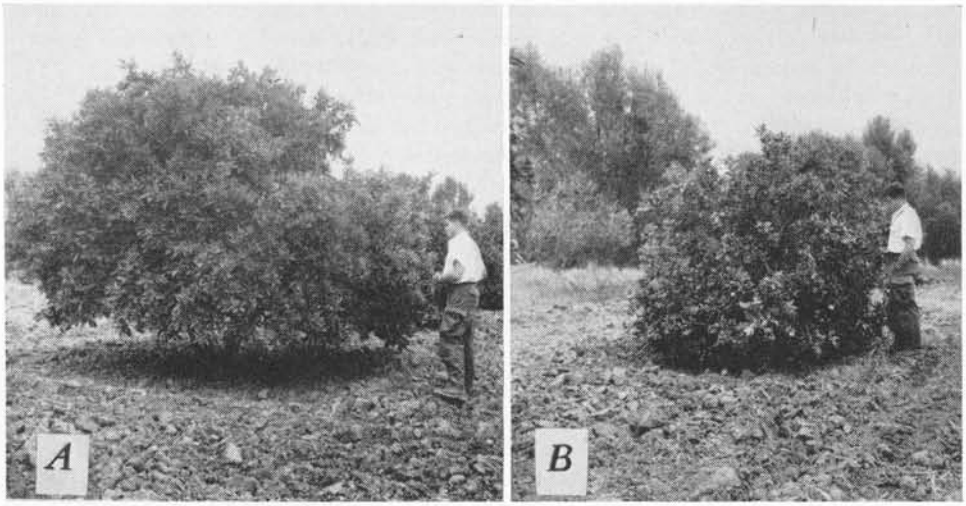

Fig. 7. Nine-year-old trees of Grosse Sanguine orange affected by stubborn disease in Morocco: A) tree with one-sided development of symptoms; B) a generally affected tree showing uniform dwarfing.

There is absolutely no doubt that numerous other species are affected by the disease. Among the known susceptible types are the true mandarins, *Citrus reticulata* Blanco; hybrid mandarins (Temple, Campeona); oranges, *C. sinensis* (Linn.) Osbeck; grapefruits, *C. paradisi* Macf.; and some interspecific hybrids like Bergamot orange. However, certain varieties of these species have never shown the disease.

Fortunately, in Morocco, some orange varieties (Moro and Tarocco Italian blood oranges) and a mandarin-hybrid variety, the Wilking, apparently are not affected. We do not know at the present time if these varieties are tolerant or resistant. It seems more plausible to us that by chance they have not become infected.

IDENTIFICATION OF STUBBORN DISEASE

One of the most conspicuous symptoms of this disease is the acorn-shaped fruit found on many trees. Thus, as far as this character (acorn-shaped fruit) is specific for the stubborn disease described in California, we have concluded that one disease present in all the Mediterranean countries is the stubborn disease, also called crazy-top or acorn disease.

However, we have never seen symptoms like the "pink nose" or the "blue albedo" which are encountered in California. On the other hand, we have noticed in the Mediterranean area some symptoms which are not encountered in Arizona or California; for instance, tangelo-shaped leaves, closing of the navel, and curvature of the fruit axis, forming thus a lopsided fruit.

Dr. Reichert believes and has indicated in one of his publications (7) that the lopsided fruits are due to xyloporosis, and, furthermore, that those people who are talking so much about the "stubborn" disease are themselves stubborn.

We do not quite agree with Dr. Reichert when he says that the curvature of the fruit axis is due to xyloporosis. We believe that this curvature may be attributed to the "little-leaf disease," which in our minds is very different from xyloporosis.

If one does not believe in the presence of the stubborn disease, how can one explain the existence of acorn-shaped fruit, a symptom which has nothing to do either with xyloporosis or with the so-called little-leaf disease?

A third possible explanation or identification of the disease under discussion brings up the following question: Could it be that one faces here in fact not one disease, but two? If so, one of them has to be the stubborn disease of Arizona and California, in order to explain the acorn fruit. The second one would have to account for the lopsided fruits, and could be something like xyloporosis or little-leaf disease.

In conclusion, we feel that there may be more than one disease involved in the production of the symptoms we have described, but we would be very much surprised if one of these diseases would not be the stubborn disease. Anyway, whatever the disease may be, it is now well characterized in the Mediterranean region and appears to be spreading over the whole area. Thus, it is urgent that citriculturists in the countries of this region work for a true understanding of the nature of this disease or disease complex and find, if possible, a means of controlling or preventing it.

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