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A Historical Case: “*Chlorose Infectieuse des Citrus*” (Infectious Chlorosis of Citrus), First Experimentally Graft-transmitted Disease of Citrus

J. M. Bové and M. Garnier

ABSTRACT. In 1913 L. Trabut published a short paper on a lethal disease called “*Chlorose infectieuse des Citrus*” (Infectious chlorosis of citrus) which he had studied in Algeria for 12 yr. He noticed it especially on a Washington navel imported from England, where it was maintained in a glasshouse, and a Siletta sweet orange from Australia, but noted that it also occurred on other cultivated citrus. He was able to propagate the symptoms by grafting, and to transmit it by graft-inoculation. Infected rootstocks top worked with apparently healthy material passed the condition onto the scion. Suggestions that the agent was the same as the cause of infectious variegation are unlikely because of significant differences between the two, thus the origin and cause of the first experimentally graft-transmitted citrus disease remains unknown.

A short paper by L. Trabut on a lethal disease called “*Chlorose infectieuse des Citrus*” in French, or “Infectious Chlorosis of Citrus” in English, was presented by Mr. Guignard to the French Academy of Sciences in Paris, and published in 1913 in the proceedings of the Academy (6). Translation of this paper from French into English, in trying to keep as close as possible to the French text, is as follows:

“BOTANY.—ON INFECTIOUS CHLOROSIS OF CITRUS. NOTE OF MR. TRABUT, PRESENTED BY MR. GUIGNARD.

It happens in orange groves that certain trees show to be affected by a severe chlorosis, which, after increasing in intensity for two to three years, brings about decline and death of the tree.

This chlorosis presents very particular characteristics, which enable it to be distinguished from ordinary chlorosis, generally due to intoxication by the salts of the soil.

Its major characteristic resides in its very evident transmission by grafting; this is why I propose the name “infectious chlorosis”.

For about twelve years, I have observed this evil, and witnessed

that all budwood sticks taken for graft-propagation on a contaminated tree, will only produce chlorotic trees from the second year on. These trees decline more or less rapidly, and finally die.

The rootstock itself is contaminated, and goes down with the same evil, once the grafted scion has been removed. When such a contaminated, scion-free tree is regrafted, the disease moves into the new grafted part.

I have observed the infectious chlorosis essentially on two varieties: a Washington navel sweet orange tree from England where it had been grown in the glasshouse, and a Siletta sweet orange introduced from Australia as budwood. However, this disease can be observed on the other cultivated Citrus varieties.

The infected grafts grow vigorously for the first year: from the second year on, one observes an extraordinarily abundant flowering followed by a very accused carpmnia. It is at this time that one sees the first symptoms of decline; leaves turn yellow, but in a very special manner; the discoloration shows itself along the principal vein over a width of 3 to 5 mm on each side, then it follows the lateral veins. At this stage, the leaf takes a particular

aspect; destruction of chlorophyll continues, and soon the whole leaf is discolored.

This inoculable chlorosis does not seem to have been described in America where diseases of Citrus are the subject of solid research by specialists of plant pathology; however, it shows quite some analogy with infectious chlorosis of Malvaceae of V. Baur. (Kön. Preuss. Akad. Wiss. 1906), a disease which, to be true, is only an inoculable variegation.

*In practice, it is easy to be protected from this disease, **which is transmissible only by grafting**; very many experiments leave me no doubt about this.*

The nature of the contagious agent remains to be determined. I have looked in vain for a Bacteriaceae in the phloem and in the cells undergoing discoloration.

For the moment, one can admit Baur's hypothesis; the disease would result from a phytotoxin secreted by an organism which escapes investigations under the microscope, but which reveals itself by the aftermaths of inoculation."

Louis Charles Trabut was a well-known horticulturist who carried out most of his work on citrus in Algeria. He was born in Chambéry, Savoie, France on July 12, 1853, and died in Algiers on April 25, 1929. He served as Director of the Botanical Services of the General Government of Algeria, and professor at the faculty of medicine in Algiers; in July 1918 he was elected a corresponding member of the French Academy of Sciences. He is the one who noted and selected the Clementine mandarin in Father Clement Rodier's garden near Oran (4, 5, 7).

Regarding chlorosis, he was impressed by the fact that the disease was graft-transmitted, and he says that this is the reason why he called it "*infectious chlorosis*". In addition, he underlines the fact that the disease is transmissible only by grafting, and that very many experi-

ments have left him without doubts about this. As seen above, the disease was transmitted not only by graft-propagation of infected budwood, but also by graft-inoculation. Indeed, rootstocks carrying affected, symptomatic scions became themselves infected, and when such rootstocks were top-worked, the disease passed into the new scions. He does not, however, state that the budwood used for topworking was healthy, nor does he mention healthy controls. In spite of this omission, there is little doubt that this "*infectious chlorosis of Citrus*" had been graft-transmitted by Trabut as early as the 1900's, and that it is, historically, the first experimentally graft-transmitted disease of citrus.

We know today, almost 100 yr later, that graft-transmissible agents are viroids, viruses, or bacteria restricted to the phloem or the xylem. Bacteria have been known to be disease agents in animals since 1876 and in plants since 1885. Trabut looked for bacteria in the phloem, but did not see any. Sieve tube-restricted bacteria (phytoplasmas) were not detected until 1967. Viroids were discovered only in the early 1970's, and Trabut could not have been aware of them. He could, however, have known about viruses, since the first virus (*Tobacco mosaic virus*) was discovered in 1892 by D. Ivanowski, and rediscovered in 1898 by M. Beijerinck, but Trabut gives no indication that he was aware of viruses.

What are the relationships of Trabut's Infectious Chlorosis (IC) with diseases known to us? According to Klotz (2), Trabut's disease may have been Infectious Variegation (IV). Roistacher (3) also refers to it as IV. It is true that fruit and leaf symptoms of IV have been seen on sweet orange trees near Algiers and Oran by Bové (1). However, as pointed out by Wallace (8), symptoms of IC and IV are different. Among the symptoms of IC Trabut

does not mention, are leaf variegation and crinkle, so characteristic of IV. Had these symptoms been present in the affected trees, Trabut would undoubtedly have mentioned them. Also IC, but not IV, is lethal. In fact, symptoms of IC, as described by Trabut, do not fit those of any other reported diseases of citrus. Trabut's 1913 paper on IC (6) is apparently the only one he published on the disease. The disease

probably disappeared, since, as stated by Trabut, the affected trees decline and die. It will probably never be known what disease and what agent were involved, or what its origin was. Was it introduced with the Washington navel tree from England or the Siletta sweet orange budwood from Australia, or was it already present in Algeria at the time of these introductions? These questions remain unanswered.

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