

Etiology, History and World Situation of Citrus Huanglongbing

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Citrus Huanglongbing (HLB) (ex-citrus greening) is now widely considered to be the most serious disease of citrus worldwide, and has been responsible for the loss of millions of trees in Asia, Africa and the Americas. For several decades, it was known only in Asia and Africa, but its detection in Brazil in 2004, and Florida in 2005, and its subsequent spread to several other countries in the Western hemisphere has placed HLB at the top of the global citrus health agenda.

HLB is a complex disease, with several characteristics making its detection and management problematic. One particularly challenging aspect is the long latent period, during which a healthy-appearing tree can serve as a source of infection. Although no causal microorganism has been obtained in a sustained pure culture, there is now no doubt that the disease is caused by species of the bacterial genus *Candidatus Liberibacter*. The bacteria are restricted to the phloem sieve elements of the host plant, and natural transmission is by species of citrus psyllids. Although the symptoms are the same, three species of *Ca. Liberibacter* have been associated with HLB thus far, and they differ primarily in temperature sensitivity. *Ca. L. asiaticus* (Las), the more heat tolerant species, occurs in all Asian countries where HLB occurs, while in Africa only *Ca. L. africanus* (Lam), a less heat tolerant species, has been identified (although a sub-species has been detected in an indigenous rutaceous tree). In Brazil, neither Las nor Laf were initially detected in trees with HLB symptoms, but a previously unknown species was found and named *Ca. L. americanus* (Lam). Soon after, Las was detected, and has since begun to dominate over Lam. Other HLB-infected countries in the Americas have only reported Las. In addition, HLB-like symptoms have been found in Brazil and China associated with *Ca. Phytoplasma* spp., and stubborn caused by *Spiroplasma citri* in California, several Mediterranean countries and the Middle East has very similar symptoms. The symptoms, therefore, all appear to be manifestations of phloem disruption.

The vectors of HLB are the Asian citrus psyllid, *Diaphorina citri*, in Asia and the Americas, and the African citrus psyllid *Trioza erytreae* in Africa. While experimentally, both can transmit Las and Laf, the heat sensitivities of the insects match those of the bacteria, i.e. Las transmitted by *D. citri* and Laf by *T. erytreae*. Lam is transmitted by *D. citri*.

Psyllids feed on several species of Rutaceae in addition to citrus. Some are suitable for psyllid reproduction, while others are not. Only a few of these Rutaceae have been shown to be hosts of *Liberibacter* – *Murraya* spp. (Las, Lam), *Limonia acidisma* (Las), *Severinia buxifolia* (Las), *Clausena lancium* (Las), *C. anisata* (Laf) and *Vepris undulada* (Laf). The bacteria have also been transmitted experimentally to periwinkle, dodder and tomato. The severe symptoms in citrus, and the fact that all species are susceptible, indicate that citrus is a recent host, and that native Rutaceae are most likely the original hosts. As land was cleared for expanded citrus cultivation, bacteria-carrying psyllids were attracted to these trees and probably introduced the pathogens.

The origins of HLB remain unclear, and earlier theories of a Chinese origin have been largely disproved. The first scientific evidence of the disease was published in India

in 1927, where the damage described was ascribed to *D. citri*, although they are identical to HLB symptoms, and was not reported in other places where the psyllids existed. A description of citrus die-back in India in the 18th century may have been HLB, while the 'yellow shoots' seen by Chinese farmers in the late 18th century were probably not HLB. Presumably, Las was probably transmitted to citrus by psyllids from an unidentified rutaceous species in India sometime before the 1920s. There is evidence of the movement of citrus plants from India to South East Asia and into China. If any of these plants were infected with HLB, this could be the source; HLB was first clearly described in 1938, and subsequently spread across the south of China. Other Asian nations were known to have received citrus plants from China, which would explain the sequence of HLB-detections through Indonesia, Philippines, Thailand, and Malaysia from the 1940s to the 1970s.

HLB in Africa was first observed in the late 1920s in the north-east and north-west of South Africa where citriculture was expanding. Native Rutaceae, *V. undulata* and *C. anisata*, have been described as the original hosts of *T. erytrae*, and could be the original hosts of Laf. It is not known if infected citrus was transported north to other African countries, or if Laf infected citrus from native rutaceae outside South Africa, but HLB is now known throughout eastern Africa at altitudes above 700m where temperatures are cooler. Laf is also known in the Arabian peninsular and several Indian Ocean islands; Las is also present at lower altitudes in these islands and Arabia.

D. citri was known in Brazil in the 1940s, several decades before HLB detection. Since Lam was initially the dominant species, but is now being replaced by Las, it is likely that it was introduced into Brazil first, followed at a later date by Las. Lam has since been detected in China. Importation of infected citrus plants or budwood from Asia is the most likely source. In Florida, psyllids were first found in 1998, but the first infected tree identified appeared to have been infected for several years, and within a matter of weeks HLB detections were made in many parts of south and southeast Florida. This suggests that infected plant material may have been introduced before the psyllid from Asia.

The psyllid has now appeared in several other countries in South and Central America. After its arrival in Florida, it was found in Texas in 2001, and has since been found in all other citrus producing states. HLB has been confirmed in Louisiana, Georgia and South Carolina. HLB has also spread to the Caribbean nations of Cuba, Jamaica, Puerto Rico, Dominican Republic and US Virgin Islands, and to Belize and several Mexican states.

In Asia, HLB has continued to spread. It has recently moved westwards into eastern Iran, thereby threatening Mediterranean citriculture, and eastwards into Papua New Guinea, a serious threat to Australia.

The absence of any natural resistance means that the only means of managing HLB is to start plant production with clean seed and budwood sources maintained under insect-resistant screens, and to control psyllid populations. In the future, some form of resistance as a result of genetic manipulation, is a possibility, with some initial results offering promise. This disease will be with all of us for many years, but it is encouraging to know that citrus production still continues in those countries where the disease is endemic.