

# History Lessons Towards Proactive Citrus Canker Efforts in Texas

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## ABSTRACT

Citrus canker was introduced into the United States (Texas, Florida, Louisiana and Mississippi) on infected trifoliolate orange (*Poncirus trifoliata*) and Satsuma (*Citrus unshiu*) seedlings imported from Japan in the early 1900s. An eradication campaign successfully eliminated the disease in Florida by 1927, Louisiana by 1940 and Texas by 1947. Citrus canker was also introduced into South Africa and Australia around the same time. Eradication campaigns were conducted; the disease has not returned to South Africa, but two outbreaks occurred in Australia in 1991 and 2004. In Florida, the disease also returned in 1986 and 1995, and has become endemic. Statewide surveillance for canker in Texas is now a continual activity, combined with surveys for other diseases such as huanglongbing; no canker infected trees have been found in Texas thus far.

*Additional Index Words:* infection source, eradication, risk assessment.

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Citrus canker is a serious disease caused by the bacterium *Xanthomonas axonopodis* (Gottwald et al., 2002). There are different pathovars of the bacterium; the most serious is the Asiatic form (canker A), caused by *X. axonopodis* pv. *citri* (Xac) which is the most severe and widespread form. It occurs in over 30 countries in Asia, the Pacific and Indian Ocean Islands, South America and Florida (Gottwald and Graham, 2000). Lee (1918) speculated that southern China may be the center of origin of citrus canker, but the oldest herbarium evidence of Xac goes back to more than 185 years on citron leaves from India collected between 1827 and 1831 and maintained in the Royal Botanical Gardens, Kew, UK. (Fawcett & Jenkins, 1933). There is also an infected Mexican lime specimen in Kew collected from Indonesia in 1842-1844 (Fawcett, 1936).

In this paper, we review outbreaks of citrus canker in different countries and states and the attempts at its eradication, with particular attention to the situation in Texas, and draw some conclusions for the citrus industry of Texas.

Generally, eradication programs have been successful in keeping some areas canker-free. In South Africa, where the disease was reported in 1916 on grapefruit trees imported from Florida (Doidge, 1916), an eradication campaign was launched (Doidge, 1920), with no reappearances being reported in subsequent decades (Moll, 1985). In Australia, canker was found in the Northern Territory in 1912 probably on infected trees imported from Japan or China. It was eradicated

in the Northern Territory in the 1920s but was detected again in 1991 (Broadbent et al., 1995). Canker was also found in Queensland in 2004, initiating another eradication program (Gambley et al., 2009). In Brazil, it was first identified in 1957 in the state of São Paulo, probably introduced on illegally imported budwood from Japan (Rossetti, 1977). Removal of infected trees to eradicate canker has been conducted over many years, but the disease is still present, although at low levels – 0.17% in 2008 (Massari et al., 2005; Bassanezi et al., 2009). It was estimated tree removal has cost over \$116 million during a 10-year period in Brazil (Bassanezi et al., 2009).

The bacteria are dispersed by wind and rain; when there is free water on lesions, bacterial cells ooze out and can be spread to other plants (Timmer et al., 1991). Leaves, stems and fruit can develop lesions. On leaves, the symptoms normally appear after 7 days under optimal temperature conditions as very small, slightly raised blister-like lesions which later turn tan with water-soaked margins and a chlorotic halo.

In the United States, canker was introduced accidentally through trifoliolate orange (*Poncirus trifoliata*) seedlings and Satsuma (*Citrus unshiu*) trees shipped from Japan in the early 1900s to Texas, Mississippi, Alabama and Florida (Stevens, 1914). In Texas, the first disease symptoms were noticed in 1911 on trees from Japan. Berger (1914) conducted a survey and found canker symptoms in Port Arthur, TX on ‘pumelo’ (*sic*) (possibly grapefruit), trifoliolate orange, sweet orange, satsumas and other mandarins, in Alvin,

TX on Duncan ‘pumelo’ (*sic*), trifoliolate orange, sweet orange and lemons, but did not find any in the Lower Rio Grande Valley (LRGV). A quarantine and eradication program was initiated in 1915 in Florida as illustrated in the Florida Department of Agriculture Quarantine No. 19 (Division of Plant Industry, Gainesville, FL), with similar programs being organized by the federal government in Alabama, Georgia, Louisiana, Mississippi, South Carolina and Texas (Dopson, 1964). In Florida, canker was not detected for several years after 1927 (Dopson, 1964) until 1986 when it was re-discovered near Tampa. After concerted efforts, canker was declared eradicated again in Florida by 1994 (Stall and Civerolo, 1991); however it was discovered again in 1995 in urban Miami (Schubert et al., 1996), triggering off a major renewed eradication campaign. In 2004, several hurricanes occurred over Florida, resulting in a dramatic spread of the disease (Irey et al., 2006); the eradication program was terminated in early 2006 (Bouffard, 2006) in an effort to learn to live with canker.

**South Texas Situation.** Although Berger (1914) did not observe any canker in south Texas, there was a report in The Brownsville Herald that in March 1920, approximately 7,000 trees were destroyed by federal officials in Donna, TX to control the spread of the disease (N. Rozeff, personal communication, 2007). Another indication of where canker was found in Texas was found in a collection of old photographs found in 1999 in the Department of Plant Pathology, Texas A & M University, College Station by Dr. T. Isakiet. There were several photographs of symptoms on leaves, twigs and fruit collected in Kingsville, TX in 1915, and in Alvin from 1916 to 1919, taken by Dr. J. J. Taubenhause, plant pathologist in the Texas Agriculture Experiment Station, College Station, TX (Figs. 1-5).

According to Dopson (1964), two infected trees were found in Corpus Christi, TX in 1943; this was the last canker infection found in Texas, three years after its eradication from the state of Louisiana. No canker was found in an extensive survey in Texas in 1947 (McCubbin, 1949). An estimated 27 million trees, many of them trifoliolate orange seedlings, in nurseries and groves in all the Gulf States were reported to have been destroyed by 1934 (Dopson, 1964).

**New Texas Initiatives.** The re-emergence of canker in Florida in the 1990s raised concerns in Texas, and steps were taken to determine whether the disease had spread to the state. In 1999, surveys were conducted in 10 counties in both the Gulf Coast and LRGV areas for canker and leaf miner (CLM) damage, the latter because tissue damaged by this insect which first appeared in Texas in 1994 (Legaspi et al., 1999) is ideal for canker lesion development. No can-

ker lesions in any of the 1,328 samples collected, including 122 samples with various foliar symptoms which underwent laboratory assay (Skaria et al., 2005). Active CLM infestations with associated severe foliar damage were observed at most survey locations.

In 2000, another survey was conducted in Cameron County in the LRGV (Skaria, 2004; Skaria et al., 2005). A total of 822 samples were collected and assayed based on suspected lesion morphology and microscopy. One grapefruit leaf sample had a brown circular raised lesion on the upper surface, surrounded by a clear yellow halo. Typical canker-associated water soaked margins and sunken centers were not observed. Bacterial streaming was observed in the laboratory, but attempts to culture *Xac* on selective medium (yeast-dextrose-CaCO<sub>2</sub> – YDC) did not produce positive results with the presence of 1-3 micron size, elliptical, slimy bacteria with polar flagellum. Five hundred samples from the Gulf Coast area were also collected and were found free of the disease.

Dopson (1964) mentioned the existence of *P. trifoliata* seedlings along bayous and swamps in Louisiana. Skaria (2004) surveyed 81 sites along the Texas Gulf Coast and found thousands of wild trifoliolate seedlings, some in clusters of 50-60 trees, but none was found with canker. Canker was commonly found on trifoliolate orange in the surveys conducted by Berger (1914), and the large numbers of these trees still present in TX provides an ideal host for any introduced canker bacteria.

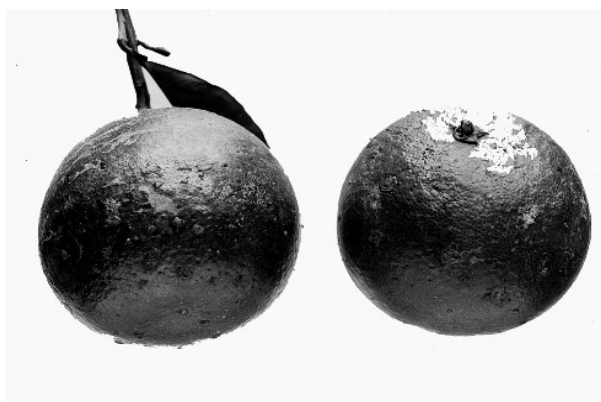
Since the discovery of citrus huanglongbing (greening) in Florida in 2005 (Halbert, 2005), surveys have been ongoing in Texas to determine whether the disease is present (da Graça et al., 2008a, b). At the same time, trees across the state are being examined for citrus canker. Citrus, both commercial and residential, in 87 counties have been surveyed, and no canker-like symptoms have been observed thus far.

The fact that canker was present in Texas for about 30 years means that it could readily become re-established, especially in the Gulf Coast areas where the climate is more favorable for canker spread (Gottwald et al., 2009). However, since canker was photographed in Kingsville (Fig. 1), and apparently observed in the LRGV (Brownsville Herald, N. Rozeff, pers.comm.), citrus throughout the state should be considered vulnerable to possible canker infestation, especially considering that 70% of the commercial orchards in the LRGV are grapefruit, a highly susceptible species (Gottwald et al., 2002). The most likely source would be infected plants as occurred 100 years ago, rather than on fruit with symptoms since Gottwald et al. (2009) demonstrated that harvested and packinghouse-disinfected fruit are a highly unlikely pathway for canker to be spread to new areas.

**Table 1.** An historical snapshot of citrus canker situations in different countries.

| Country                               | Year Found                         | Source                                              | Current Status                          |
|---------------------------------------|------------------------------------|-----------------------------------------------------|-----------------------------------------|
| United States                         | 1910                               | Trifoliate rootstock from Japan                     | Endemic in Florida<br>Not present in TX |
| Brazil                                | 1957                               | Mexican lime from Japan                             | Under control                           |
| South Africa                          | 1916                               | Trifoliate rootstock from Japan                     | Eradicated                              |
| Australia                             | 1912; Re-detected in 1991 and 2004 | Japan or China; unknown                             | Eradicated                              |
| India (may be a center of origin)     | 1827-1831                          | Herbarium material of citron in the Kew Gardens, UK | Endemic                                 |
| Indonesia (may be a center of origin) | 1842-1844                          | Mexican lime in the Kew Gardens, UK                 | Endemic                                 |
| China (may be a center of origin)     | ?                                  | unknown                                             | Endemic                                 |


**Fig. 1.** Citrus canker lesions on sweet orange fruit, Kingsville, TX (1915).

**Fig. 2.** Canker lesions on Satsuma leaves in Texas (October, 1916).

**Fig. 3.** Canker lesions on Louisiana sweet orange fruit, Alvin TX (October, 1916).

**Fig. 4.** Canker-infected citrus twigs in Texas (June, 1919).



**Fig. 5.** Dr. J. J. Taubenhaus, plant pathologist with the Texas Agricultural Experiment Station, College Station, who photographed citrus canker symptoms in Texas (1915-1919).

## CONCLUSIONS

- A concerted eradication of infected plant material is the best control strategy if canker ever re-appears in Texas. This is a proven plant pathology protocol for any economically damaging disease-host situation(s). Though the use of resistant cultivars is a theoretical possibility to avoid destructive diseases, none has proven practically possible thus far for canker. Proper, practical risk assessment and implementation protocols should be developed.

- A high economic and a potential trade embargo of canker in Texas can become an emotionally charged situation. Lessons learned in Florida, especially with the success and/or failures of certain principles have to

be implemented in a way incorporating the support of a wider section of the population representing all interested parties.

- A sensible risk assessment that includes the pathogen, trade issues, fiscal matters, and legal issues – all have to be carefully evaluated in the background with all lessons learned from abroad and Florida.

## DEDICATION

The authors wish to dedicate this review to the memory of a valuable friend, scientist and a contributor towards the understanding of citrus canker epidemiology – Dr Paul Parker (1948-2010), former Director of the USDA-APHIS-CPHST Center, Edinburg, TX.

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