

The History And Rediscovery Of Citrus Canker In Florida

By JACK O. WHITESIDE

This article discusses the disease known as citrus canker, Asian canker, or canker A, caused by *Xanthomonas campestris* pv. *citri*. It is not concerned with the bacterial disease first discovered in Florida citrus nurseries in 1984, caused by an apparently endemic (2) *Xanthomonas* bacterium which causes a disease variously named as canker E, nursery form of canker or citrus bacterial spot. This other *Xanthomonas* pathogen was named *X. campestris* pv. *citri* according to current rules of bacterial classification, because it was found on citrus plants. Because this other bacterial disease was considered to be canker (7) or a form of canker (6), an action plan for eradicating it was implemented by Florida state and federal plant disease regulatory authorities in 1984. The increasing publicity given to canker following this new discovery, and the intensified inspection efforts that ensued, led to the rediscovery of canker A in Florida.

Citrus canker has long been perceived in the United States as an exceptionally destructive disease (10), despite its relative unimportance compared with other diseases in most of the citrus-producing countries where it has long occurred. The fear of canker began in Florida some 75 years ago after the disease was accidentally introduced into the United States on nursery plants imported from Japan about 1910 (1). Following a lengthy tree-burning campaign, canker was declared eradicated in Florida in 1933 after no new cases were found for six consecutive years (10). In Texas, following a similar eradication campaign, canker was last found in 1943 (10).

Surprisingly, there are no records of anyone ever challenging the conclusion reached in 1933 that all the canker outbreaks in Florida had been found and that the disease was, therefore, eradicated. Yet, if one considers the nature of the disease, its epidemiology, and the difficulties of thoroughly inspecting the foliage for canker lesions, particularly

on larger trees, it seems unreasonable to believe that canker disappeared from Florida because of the eradication efforts alone. The following question must be asked. Did canker really disappear in Florida by 1933 or did some remnants of the disease remain after this time? This question needs to be seriously considered, even if it cannot be definitely answered. The canker found recently in central Florida near the Gulf of Mexico could just as logically represent a remnant from the past as a more recent introduction. It is necessary to ask whether it is realistic to believe that the canker pathogen could ever be eradicated without first eliminating its host on some massive scale. Furthermore, it is necessary to reconsider if canker could ever be serious enough under Florida conditions to justify a prolonged, extremely expensive and highly uncertain eradication campaign.

The main purpose of this article is to consider these questions by, 1 - drawing attention to some key features of the disease, 2 - reexamining the old records of canker in Florida, 3 - considering the behavior of canker in Argentina, where the environmental conditions somewhat resemble those in Florida and where the disease has been present for some 25 years, and 4 - referring to some observations on the recent rediscovery of canker on Florida's Gulf Coast.

Some Key Features Of Citrus Canker And Its Causal Agent

Canker appears on leaves, fruit and stems as raised pustules with a yellow halo. The infection does not become systemic; that is, the canker bacteria do not move far from their point of entry. Canker bacteria invade leaves only while they are still young, but generally not before they have partially expanded. Because of a delay in susceptibility, there is little or no leaf distortion as characteristic of such diseases as scab (*Elsinoe fawcettii*) and melanose (*Diaporthe citri*) which attack shoot tips and leaves as soon as they begin to differenti-

ate from the bud.

Defoliation from canker mostly occurs while the leaves are still young. While the defoliation caused by canker sometimes causes dieback, this seldom has any longterm impact on tree growth. Loss of new growth can be rapidly compensated for by growth of new shoots from buds located below. Unless frequently repeated, canker-induced defoliation has less impact on tree development than a disease like greasy spot (*Mycosphaerella citri*) which causes abscission of older leaves during the fall and winter, resulting in loss of vigor of the spring growth flush. In most countries where canker is endemic, it causes little or no tree debilitation. Essentially, canker is economically significant as a fruit disease, varying from a minor rind blemish to a more serious rind blemish with varying amounts of fruit drop depending on how conducive the climatic conditions are for infection.

Fruit remain susceptible to attack for about 3 months after petal fall (9), and the earlier the infection occurs the larger the resulting lesions. Fruit drop is more likely to occur with early infection. When the climate is relatively dry during the first 3 months after petal fall, fruit infection is rare or absent.

Water is essential for the release of bacteria from canker pustules and a water-splashing action is needed for their dispersal. Water is also needed for host penetration. Infection occurs mostly through stomata but can also occur through wounds. Wind has a major influence on disease severity. Wind speeds above 10 mph during rainstorms greatly increase the chances for infection (8). Fruit on the side of a tree exposed to wind-driven rain develop more canker lesions than those on the sheltered side of the same tree. The planting of windbreaks on the side of a grove exposed to wind-driven rain is an important control measure in countries where the disease can be serious (4,5). Old trees are less prone to canker than young trees. This is partly because of the natural sheltering from wind that occurs in groves of larger trees and partly because younger trees flush more frequently, thereby increasing the

Dr. Jack Whiteside is with the Citrus Research and Education Center, Institute of Food and Agricultural Sciences, University of Florida, Lake Alfred, Florida.

chance of susceptible shoots being present when climatic conditions favor attack.

The Early History Of Canker In Florida

Canker apparently originated with its citrus host in East Asia. Canker was first discovered in the United States in 1912 in Florida and the other Gulf states (1). It was accidentally introduced on some citrus plants imported from Japan about 1910. At first, the disease was thought to be scab, but in 1915 it was described as a bacterial disease (3). In 1915, Stevens (12) projected, without providing any convincing data, that if canker persisted it would be uncontrollable and even kill trees. Berger (1) also expressed serious concerns about the disease, but qualified his remarks by mentioning that little fruit infection had been observed. Growers expressed the greatest concern in Dade County. Yet, the only published information on fruit losses I have been able to find was by Stirling (13) in 1914. In a 7-year-old Dade County grapefruit grove, he estimated fruit losses from canker at 12 boxes per acre. I found no reports in the old Florida literature of any consequential damage to trees.

There seems to have been no scientific basis in Florida for declaring canker a devastating disease. Nevertheless, in May, 1915, following the enactment of the State of Florida Plant Act and the formation of the State Plant Board, a canker eradication program was initiated in conjunction with the U.S. Department of Agriculture. Citrus nurseries and groves were subsequently inspected regularly for canker. Part or all of those nurseries that had canker were destroyed by burning. In groves, only those trees which were observed to have canker pustules had to be burned. Thus, the measures used in infected groves were much less drastic than in nurseries.

Back in the teens and twenties, canker pustules apparently were considered to be conspicuous enough for inspectors to readily find. Yet, some canker pustules are less than 2 mm in diameter; so small they could be missed even by close inspection. The yellow halo that characterizes canker pustules when young, regreens after a few months making it even more difficult to locate the pustules. Nursery inspections were apparently done thoroughly enough to detect small amounts of canker, but this was probably not the case in mature groves. New finds of canker in groves dropped rapidly from 1915 to 1916 (11). By this time, little canker remained in the nurseries and very few infected trees were moved

thereafter into the groves (15).

Prior to December 31, 1916, 13,336 grove trees were recorded with canker. After that date and until the last find in 1927, only 1,907 further infected trees were found. Of these, 540 trees were present in three adjacent groves at Boynton Beach in 1920, 873 trees were present in 15 groves at Davie in 1922 and 85 were found in a single Fort Lauderdale grove in 1927 (11). If canker bacteria were able to spread rapidly in groves and cause heavy infection, the disease would have spread widely in groves before the planting out of diseased trees was stopped. Because it did not spread widely or apparently persist in most groves, it was probably mainly self-eliminating. The discoveries in 1920, 1922 and 1927 are interesting because they occurred after canker had been eradicated from the nurseries. Perhaps these outbreaks represented a remnant from earlier introductions which had been previously missed by the inspectors. After canker was declared eradicated in 1933, canker inspection surveys were curtailed. This may explain why canker was not found again until the mid-1980s, after surveys were intensified and more publicity was given to the disease.

The History And Behavior Of Citrus Canker In Argentina

In Argentina, there has long existed another form of canker called canker B or cancrrosis B which may have originated in that country. Cancrosis B mostly affects lemons. It is considered distinct from canker A and will not be discussed here.

Canker A was not observed in Argentina until 1964 (4). It is thought to have reached that country via Brazil, where it was first recorded in 1957 (10) after apparently being introduced on illegally imported plants from Japan. Canker A is now widely distributed in Argentina's citrus-producing provinces of Misiones, Corrientes and Entre Rios, but is generally of minor importance.

The Argentine experience with canker is of particular interest to the Florida citrus industry because of similarities in climate, production methods and the commercial varieties grown. There are, however, sufficient differences between the climatic conditions in Argentina and Florida to suggest that canker would be even less troublesome in Florida than in Argentina (14). Although the rainfall in the canker-affected areas of Argentina is about the same as in Florida, averaging 50 inches per annum, the seasonal distribution is different. Rain-

fall during the emergence of the spring growth flush is more frequent than in Florida (14). Therefore, in Florida there is less possibility for a build up of inoculum prior to fruit development. Furthermore, rainfall in Florida during the first month after petal fall is less frequent than in Argentina (14). This would reduce the risks of early infection in Florida, with less chance of larger canker lesions being formed and of multiple infection cycles occurring on the same fruit before it becomes resistant to attack. Rainfall in the summer is higher in Florida than in Argentina but this would not promote fruit infection because the rind becomes resistant by this time.

Another difference between Florida and Argentina concerns wind speeds, particularly when it rains. Sustained high winds frequently accompany rainstorms in Argentina and this increases the chances for pathogen dispersal and infection. In Florida, even though gusty winds are frequently associated with rainstorms, relatively calm conditions usually return soon after the precipitation begins.

The worst attacks of canker in Argentina occurred in the 70s when rainfall was about 50 percent above normal for several consecutive years (4). Substantial fruit infection occurred in a few grapefruit groves, but Valencia oranges and mandarins were little affected. Following a resumption of more normal rainfall and the application of appropriate control measures, the incidence of the disease has declined, even in the previously afflicted groves.

One particularly important lesson that should be learned from the Argentine experience is that the incidence of canker can vary greatly from year to year; frequently dropping to such low levels that it is difficult or even impossible to find any new symptoms on previously infected trees. While traces of inoculum may still remain in such groves, this decline gives a semblance of self-elimination. A similar disappearing act has been observed in some Florida groves with scab. Scab is also a disease which depends on rain for infection and spread, and which infects leaves, stems and fruit rind only while they are young.

Observations On The Recent Rediscovery Of Citrus Canker On Florida's Gulf Coast

The presence of canker on some dooryard trees in a residential area of Pinellas County was confirmed in 1986. Later, it was found on many dooryard trees on Anna Maria Island and on the mainland of Manatee County, and on a few door-

yard trees in Sarasota County. On one of the Key lime trees I examined on Anna Maria Island, there were stem lesions that were at least 3 years old. Some residents reported seeing leaf and fruit spots, that might have been canker, even back in the seventies, but did not worry about them because there was little fruit loss. In 1986, a localized and very mild outbreak of canker was discovered in a commercial grove at Palmetto, Manatee County. This is still the only commercial grove to date in which canker A has been found. The nursery form of canker has never been found in a grove.

There appeared to be no logical recent link between the canker discoveries in these three Gulf Coast counties. Some of the locations were separated from the nearest known infections by as much as 10 miles, which in some cases included wide water barriers. No canker A has been found in Florida nurseries since 1922 and it is, therefore, unlikely that it originated from any recently transplanted trees. At all locations, the disease was very localized. While some trees carried infected leaves and fruit, nearby ones, even of the same variety, often appeared to be disease-free. Such a restricted occurrence of symptoms does not fit the concept of canker being an aggressive disease under Florida conditions. Rather, this is the type of patchy disease occurrence that occurs when the environmental conditions are marginal for infection.

Recent spread of canker in the Gulf Coast counties by some airborne means seemed highly unlikely because of the long distances between the different locations. More likely, this disease had been present on Florida's Gulf Coast for many years. If it had not been for the increased vigilance that followed the recent discovery of the *Xanthomonas*-induced disease in Florida nurseries, the canker on the Gulf Coast may never have attracted attention.

The idea of canker on the Gulf Coast being a remnant from the distant past is a concept that is difficult for those who favor the current canker eradication philosophy to accept. Nevertheless, this idea needs realistic consideration. Extensive plantings of citrus already existed by 1910 in those Gulf Coast areas where the disease has recently been discovered. If the canker there is a remnant from the early part of this century, any losses in production that were incurred were apparently too small to cause concern to the owners of the citrus trees.

The Prospects For Eradicating Canker In Florida

The present canker eradication cam-

paign is based on the premise that since canker was supposedly eradicated during the teens and twenties, this apparent success can be repeated. Yet, there is no certainty that canker was completely eradicated in groves during the previous campaign. The sudden reduction in new finds in citrus groves after 1915 could have been associated with the fact that very few infected trees were being transplanted from infected nurseries into groves.

It should be remembered that canker infected trees were being planted out in groves for 3 or 4 years before any action was taken to prevent the further movement of such trees from infected nurseries (1,12). According to the State Plant Board records (11), 338,512 trees were moved from infected nurseries prior to April, 1915 and planted in groves in 21 different Florida counties. This should have provided adequate opportunity for the pathogen to spread widely and cause significant amounts of disease, if it had the capacity to do so.

There is a very important difference between the canker A situation in Florida today and in the teens. The disease started in nurseries about 1910 and was then spread to groves on infected nursery trees. The recent canker finds on Florida's Gulf Coast have not been associated with nurseries. The rediscovery of canker A in 1986 could be likened to the discoveries made in localized areas in 1920, 1922 and 1927 in Boynton Beach, Davie and Fort Lauderdale, respectively. Those outbreaks could hardly have been recent introductions from infected nurseries. The numbers of nursery trees found with canker after 1916 were very small; 44 in 1917, 4 in 1918, 1 in 1919, 0 in 1920 and 1921 and 6 in 1922 which was the last year of any nursery finds (15). Perhaps the disease reached these east coast localities much earlier and escaped notice during previous inspections.

The current eradication campaign is based on a supposition that canker will eventually become detectable by visual inspection wherever it occurs, by always increasing in severity. However, we know from the Argentine experience that canker can decline in some groves to a level that is very difficult to detect by visual inspection. I believe, therefore, that it would be virtually impossible to eradicate canker from infected citrus groves unless there is extensive tree destruction around areas of noticeable infection. Such tree destruction would be intolerable to citrus growers unless there were convincing evidence they would be unable to economically

tolerate the disease.

A Reevaluation Of The Threat Of Canker To Florida Citrus Production

The measures that are currently aimed at canker eradication are costly, laborious and the prospects for success are extremely doubtful. The reasons given in 1915 and again in 1984 for trying to eradicate canker were based on misunderstandings and speculations by some authorities that canker would be so devastating to citrus trees, that the citrus industry would not survive. Such views would be considered untenable today by even the most hardline canker observers.

If canker were really capable of causing much fruit infection in Florida, this should have become evident during the teens. After all, infected trees were being planted on new sites and as resets in existing groves long before this was stopped by government action. Also, if canker had a potential for being a serious problem on fruit, many more infected fruit should have been present on the trees recently found with canker on the Gulf Coast.

Another reason for believing that canker would not be a problem in Florida is based on the experience with the disease in Argentina where canker has turned out to be a relatively minor and mostly cosmetic disease (4).

If canker were a contagious and devastating disease, the eradication procedures would by this time have clearly proven themselves inadequate. As long as relatively few new cases are discovered each year, some authorities may believe the pathogen is being conquered. However, even if there are no new finds, the disease could still be present in small amounts and later become conspicuous enough to attract attention. Thus, even if there are no new finds for several consecutive years (the number of which has still to be decided by the regulators), this would not guarantee that the pathogen had been eradicated. It would more likely mean that because of unfavorable environmental conditions there was too little disease to attract attention. Later, the disease may be rediscovered, leading to a repeated canker trauma, unless there is a new and more realistic philosophy about canker by that time.

One of the reasons given for continuing the canker scare is that no one has yet proven to the satisfaction of all concerned that canker would not be an economic problem in Florida. In reality, however, no one as yet has provided any evidence that it could be a serious threat to the Florida citrus industry. Seemingly,

this matter will never be resolved to everyone's satisfaction because of continuing opposition to the idea of leaving an outbreak alone at some isolated location and putting the disease to the test. I would argue, however, that canker has already been put to the test, both back in the teens and twenties and, perhaps for as much as 75 years, on Florida's Gulf Coast.

Canker eradication efforts are also fueled by the fear of the disease in some other citrus-producing areas and the idea that some markets for fresh fruit may be permanently lost if the pathogen is still known to exist in Florida. Starting in 1914 (1, 13) and 1915 (12), it was Florida that expounded the devastating disease image of canker to other citrus-producing areas of the United States and the rest of the world. Florida authorities now need to revise this opinion and clearly indicate that the canker pathogen has some very specific climatic requirements for spread and infection. This should at least help to quiet the unnecessary fears about the disease that occur in some citrus-growing areas with dry springs and summers.

The climatic requirements for canker epidemics are even more demanding than they are for scab. Countries that have canker almost invariably have scab as well, although not all countries with scab have canker. Strangely, the concern about canker even extends to areas where no one would ever be concerned about scab. Yet, if the conditions are too dry for scab on fruit, they would certainly be too dry for canker to be a problem.

The economic threat of canker to the Florida citrus industry and to other areas where the climatic conditions seem marginal or unfavorable for infection needs to be reexamined. Furthermore, there needs to be a more scientific, practical and realistic appraisal of the canker eradication efforts, to consider if they are really needed and likely to achieve their stated goal of eradicating the pathogen. CVM

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