An epidemiological analysis of the spread of citrus canker in urban Miami, Florida, and synergistic interaction with the Asian citrus leafminer

TR Gottwald
US Deparment of Agriculture
Agricultural Research Service
2120 Camden Rd
Orlando, FL 32803
USA

JH Graham
University of Florida
IFAS
Citrus Research
and Education Center
700 Experiment Station Road
Lake Alfred, FL
USA

TS Schubert
Florida Dept of Agriculture
and Consumer Services
Division of Plant Industry
PO Box 147100
1911 SW 34 St
Gainesville, FL 32614-7100
USA

Received 6 February 1997
Accepted 6 October 1997

Fruits, 1997, vol 52, p 383-390
® Elsevier, Paris

***Resumen Español**, p 390*

An epidemiological analysis of the spread of citrus canker in urban Miami, Florida, and synergistic interaction with the Asian citrus leafminer.

ABSTRACT

BRIEF HISTORY OF CITRUS CANKER IN FLORIDA. After 12 main outbreaks of Asiatic citrus canker (ACC) caused by *Xanthomonas axonopodis* pv *citri* (*Xac*) occurred from 1986 to 1992 in Florida, a new outbreak of ACC was discovered in the residential Miami area in 1995. **INTERACTION WITH THE ASIAN LEAFMINER**. The feeding activities of the Asian Leafminer, *Phyllocnistis citrella* Stainton, facilitates the *Xanthomonas axonopodis* pv *citri* (*Xac*), infections. This generates large amounts of inoculum, promoting spread of the bacteria by rain splash. **TRACING BACK THE EPIDEMIC TO PRESUMED ORIGINS**. It was established that the present citrus canker had existed in the Miami residential area for at least 2–3 years but the origin or source of this introduction, which was demonstrated to differ from the previous outbreaks, remains unknown. **DRIVING FORCES OF A CITRUS CANKER EPIDEMIC.** Once the disease is established in an area, the most important driving factors for disease increase and spread of citrus canker are rain splash of inoculum, and wind-blown rain laden with inoculum. **EFFECT OF PAST AND PRESENT METEOROLOGICAL EVENTS ON SPREAD**. Individual meteorological events such as thunderstorms, tornadoes, tropical storms, and hurricanes apparently have contributed to medium - to - long distance dispersal of *Xac* from the original focus. **PROGNOSIS**. As a number of impediments to eradication presently exist, the eradication agency has adopted a new survey method which allows the early discovery of new infections the farthest from the focus and immediately eliminate them in an attempt to limit further spread of citrus canker.

KEYWORDS
Florida, *Citrus*, canckers, epidemiology, disease control.

Analyse épidémiologique de la propagation du chancre bactérien des agrumes dans la ville de Miami en Floride, et interaction avec la mineuse asiatique des agrumes.

RÉSUMÉ

BREF HISTORIQUE DU CHANCRE CITRIQUE EN FLORIDE. Après 12 épidémies importantes de chancre bactérien des agrumes (ACC) dû à *Xanthomonas axonopodis* pv *citri* (*Xac*), survenues de 1986 à 1992 en Floride, la maladie était de nouveau découverte, en 1995, dans le quartier résidentiel de Miami. **INTERACTION AVEC LA MINEUSE ASIATIQUE DES AGRUMES**. Par son comportement alimentaire, la mineuse asiatique des agrumes, *Phyllocnistis citrella* Stainton, facilite la pénétration de la bactérie dans les feuilles. Cela induit la formation de grandes quantités d'inoculum favorisant la dissémination de *Xac* à partir des éclaboussures de pluies. **RECHERCHE D'INDICES PERMETTANT DE DÉTERMINER L'ORIGINE DE L'ÉPIDÉMIE**. Il a été établi que l'actuelle épidémie de chancre bactérien des agrumes de la zone résidentielle de Miami y est installée depuis 2 ou 3 ans, cependant son origine, qui s'est avérée différente de celle des épidémies précédentes, reste inconnue. **ÉLÉMENTS DE DISPERSION D'UNE ÉPIDÉMIE DE CHANCRE BACTÉRIEN.** Dès que la maladie est installée en un lieu donné, les éléments de sa propagation les plus décisifs sont les éclaboussures de pluies contaminées et les averses poussées par le vent, chargées d'inoculum. **EFFET DES ÉVÉNEMENTS MÉTÉOROLOGIQUES PASSÉS ET PRÉSENTS SUR LA PROPAGATION.** Des événements météorologiques individuels, tels qu'orages, tornades, tempêtes tropicales et ouragans auraient contribué à la dispersion de *Xac* sur de moyennes à longues distances du foyer d'infection. **MESURES À PRENDRE**. Comme de nombreux facteurs gênent actuellement l'éradication, une nouvelle méthode a été adoptée qui permet de détecter toute nouvelle infestation éloignée du foyer et de l'éliminer aussitôt pour tenter de limiter d'autres propagations du chancre bactérien des agrumes.

MOTS CLÉS
Floride, *Citrus*, chancre bactérien des agrumes, épidémiologie, contrôle de maladies.

brief history of citrus canker in Florida

Asiatic citrus canker caused by *Xanthomonas axonopodis* pv *citri* (*Xac*) was first introduced into Florida by infected trifoliate orange seedlings in the early 1910s, and was followed by a federally initiated eradication campaign in 1915. Over 6 M US$ was spent on eradication which resulted in the destruction of 258 000 grove trees and 3 million nursery trees before eradication was declared in 1933 (CIVEROLO, 1984; STALL and CIVEROLO, 1991).

A second bacterial disease was discovered in Florida in September 1984 (STALL and CIVEROLO, 1991; GRAHAM and GOTTWALD, 1992). This disease, called citrus bacterial spot (CBS), is caused by a related bacterium, *Xanthomonas axonopodis* pv *citrumelo*. The disease was originally considered a variant of Asiatic citrus canker but was later determined to be a minor nursery disease of Swingle citrumelo, trifoliate orange rootstocks and a few grapefruit cultivars (GRAHAM and GOTTWALD, 1992). CBS appeared to be endemic to Florida and was later deregulated in 1990. However, the discovery of CBS initiated a joint state and federal eradication campaign. During surveys to locate CBS infections, Asiatic citrus canker was found on the Gulf Coast of Florida in June of 1986 (STALL and CIVEROLO, 1991). Examination of old lesions on infected trees indicated that the citrus canker had been in the Gulf Coast area for at least two to three years prior to detection. During the period of 1986 to 1992, 12 main outbreaks of Asiatic citrus canker occurred in citrus groves and residential areas of Florida, mostly centred around the Central Gulf coast. Following the destruction of approximately 89 000 infected and exposed trees, eradication of Asiatic citrus canker was declared in January 1994.

The latest outbreak of Asiatic citrus canker was discovered in the residential Miami, Florida area in September 1995 (SCHUBERT et al, 1996). Initial surveys delimited the infestation to 14 sections. In the United States, land can be located by its section-township-range designation[1]. As of February 1997, the infested area has increased to 86 sections.

[1] *A section is one square mile (≈2.6 km^2) in area. Townships are divided into 36 sections and thus consist of 36 square miles and are organized in North-South rows. Each North-South row of townships is designated by a range numbered East and West from a principle meridian of the original US Geological Land Survey.*

interaction with the Asian leafminer

The Asian citrus leafminer, *Phyllocnistis citrella* Stainton, was first discovered in South Florida in May 1993, and quickly spread throughout the state (HEPPNER, 1993). In the Miami area, the interaction between Asian leafminer infestation and citrus canker was immediately apparent. The leafminer infests young citrus flush, including both leaves and young stems. Young fruit, especially grapefruit, are also occasionally attacked. leafminer larvae form feeding galleries in the epidermal cell layer of young leaves and other tissues, lifting and eventually tearing the cuticle (ACHOR et al, 1996; GRAHAM et al, 1996). The feeding activities of the leafminer facilitates *Xac* infections in two ways. First, the cracking of the cuticle opens the mesophyll of the leaf to the environment and thus provides a means for direct bacterial infection of the mesophyll cells when splash-dispersed or wind-blown rain-dispersed bacteria come in contact with the leaf surface. Second, the leafminer larvae often become contaminated with bacteria which are transported through the feeding galleries. This results in numerous mesophyll infections within the galleries (GRAHAM et al, 1996). As these numerous leafminer-induced lesions expand and mature, they rupture through the epidermis and often coalesce forming massive infections covering large areas of the leaf lamina. This greatly exacerbates the infected foliar area and generates many times the amount of inoculum, compared to *Xac* infections where the leafminer is not present (GRAHAM et al, 1996). This increased inoculum potential accelerates the epidemic by promoting spread of the bacteria.

tracing back the epidemic to presumed origins

The rate of growth and aging characteristics of citrus canker lesions is relatively well understood. Therefore, the visual aspect of individual lesions can serve to estimate the age of individual infections. To determine the approximate time of initial infection, individual trees are searched to find the oldest lesions that occur. Fruit and foliar lesions are used to date recent infections less than one year old; however, infected fruit and foliage often abscise earlier than non-infected tissues. Twig and stem infections are used to estimate historical citrus canker infections because they do not abscise and remain recognizable for several years. Therefore, examining trees in an infected area for stem lesions can aid in the determination of initial infection within that area. In addition, trees can be examined to determine if infections are more heavily distributed on one particular side of the tree. If infection predominates on one side, it can indicate that inoculum was carried by wind-blown rain from the direction adjacent to the heavily infected side. Following or 'back-tracking' these infection distribution patterns, ie, disease gradients, within trees in an infected area 'upstream' toward more severe infections, can help lead investigators to the probable sources or foci of infection for that area.

These techniques were used in the Miami area to determine the approximate time that citrus canker first occurred in the area, to back-track to the probable focus of infection by examination of disease gradients, and to continue to search for foci of infection that have been overlooked. In October 1995, the authors backtracked the disease gradients within the infected area to a heavily infested residential area approximately 2 miles Southwest of the Miami International Airport. Close examination of trees within this area led to the discovery of a five-to seven-year-old lemon tree with stem lesions on wood about 2.5 cm in diameter. The number of growth flushes distal to these stem lesions was determined to be seven to eight and the age of the oldest infections within this tree was estimated at 24 to 36 months, depending on the estimated number of growth flushes the tree had produced per year. Although these lesions are the oldest found to date, the authors do not believe that this tree represents the original introduction of disease. The original infection was not found or, perhaps, no longer existed. However, it does establish that citrus canker had existed in this residential area for at least two to three years, which predates the declared eradication of citrus canker in the Gulf Coast area. However, the majority of infections within the Miami area were less than one year of age. GABRIEL (IFAS, University of Florida, Gainesville) conducted a genomic analysis of isolates of *Xac* collected in the Miami area and compared these to other isolates collected from the earlier epidemic on the Gulf Coast. This genomic analysis indicated that the Miami isolates of *Xac* were sufficiently different from the Gulf Coast isolates to conclude that it is highly unlikely that they are related. Therefore, the Miami epidemic is believed to be from a separate and unique introduction of *Xac*. The origin and source of the Miami introduction of citrus canker remains unknown.

driving forces of a citrus canker epidemic

Spread and increase of citrus canker can be caused by human transport and meteorological events (SERIZAWA et al, 1969). Human movement is the primary means for introduction of *Xac* into new areas and can also contribute to localized spread of the pathogen. The bacteria are often dispersed by infected or infested propagation materials such as budwood and potted and bare-root trees. Spread of citrus canker in the Miami area due to human transport apparently included the movement of infected plant material, fruit, and potted plants by home owners and small backyard nurseries, and spread of bacteria on moist surfaces of lawn maintenance equipment. In one case, sanitation department trucks passing through alleyways while collecting refuse brushed against infected trees and spread infections to nearby trees along the alley. Most visual evidence implies that inadvertent human transport has resulted in predominantly local, short distance spread, although long distance spread is also possible. In addition, it is possible that animals such as birds and insects can passively carry *Xac* bacteria from tree to tree. However, once the disease is established in an area, the most important driving factors for disease increase and spread of citrus canker are rain splash of inoculum, and wind-blown rain laden with inoculum (SERIZAWA et al, 1969; SERIZAWA and INOUE, 1975).

effect of past and present meteorological events on spread

Citrus canker is known to be spread locally by rain splash of bacteria from active lesions, and over long distances by wind-blown rain laden with inoculum (GOTTWALD et al, 1988, 1989, 1992; GOTTWALD and TIMMER, 1994). Winds in excess of 17.9 mph (28.8 km/h) are also known to cause water soaking of foliar tissues and facilitate *Xac* infection (SERIZAWA and INOUE, 1975). The distribution of citrus canker was consistent with disease gradients established by wind-blown rain. Because it was determined that the epidemic had been initiated at least two years prior to its discovery, and that the majority of infections within the Miami area were less that one year of age, the history of major meteorological events from 1992 to present years was examined to determine if storm events could have contributed to spread of the bacteria. In this way, the approximate time and direction of bacterial spread could be estimated. These estimations could then be used to project possible paths of spread and determine those residential areas with the highest risk of past and future infection. Such information would presumably help the eradication effort by predicting the most likely areas to look for old and new foci of infection.

Weather patterns that affect citrus canker spread can be local or regional. Local rainstorms, storm cells, and tornadoes can be generated by daily local climatic events. For instance, a common daily summer cycle in Florida results from morning solar warming of the Florida peninsula causing an upward rise of warm surface air masses. This results in onshore afternoon air movement of moist marine air from both the Atlantic and the Gulf of Mexico, stimulating rain showers and thunderstorms that can be locally severe and include high winds and tornadic activity. In the Miami area, annual rainfall is 60–65 inches (152–165 cm), occurring primarily during the period of May to October, with an average of 70–80 thunderstorms per year. There are 80–90 days per year with at least 0.1 inches (0.25 cm) of rain. During 1995, the Miami rainfall was higher than normal, 78.13 inches (198.5 cm), whereas the 1996 rainfall was 57.72 inches (146.6 cm), although some significant local storms occurred during 1996. Regional weather patterns include hurricanes, tropical storms, and cold fronts, all of which can also generate locally heavy winds, rain, and tornadoes. In the Miami area, several regional and numerous local meteorological events have occurred since *Xac* is presumed to have been introduced.

Rain showers cause canker bacteria to ooze from lesions and splash to nearby foliage where infection can take place if susceptible tissues exist (PELTIER, 1920; KOIZUMI, 1977; CIVEROLO, 1984; REEDY, 1984). When wind accompanies rain, *Xac* inoculum can spread over some distance, and if winds are strong enough, this distance can be considerable. Table I indicates the named hurricanes and tropical storms that have affected the Miami area since the presumed 1992-1993 introduction of citrus canker. The most devastating was Hurricane Andrew which passed just South of the center of Miami and caused tremendous damage. However, it was probably too early to have effected the citrus canker epidemic. If it had, citrus canker would have been much more widely spread earlier. No major storms occurred in 1993. However, in 1994 Hurricane Gordon caused considerable wind and rain which could have contributed to the localized spread of the new citrus canker introduction. In 1995, hurricane Erin passed just North of Miami and probably did not directly affect the Miami area. The single storm which probably caused the most spread of citrus canker was Tropical Storm Jerry. Jerry passed just to the North of the canker infected area of Miami and had sustained winds of 40 mph. Due to the counterclockwise rotation of the tropical storm, the winds and wind-blown rain resulting from Jerry would have been first to the East, then to the West, then to the Northeast as the storm passed. These wind directions could account for the disease distribution over several miles, as first seen in late 1995 (figure 1).

Table I
Hurricanes and tropical storms affecting Miami area and citrus canker epidemic 1992 through 1996 (*Xac*: *Xanthomonas axonopodis* pv *citri*).

Dates	*Named storm*	*Wind speed (mph)*	*Severity category*	*Wind direction*	*Effect on canker epidemic*
16–28 / 08 / 92	Andrew	135	5	South then West	Probably too early
1993	None	—	—	—	—
08–21 / 11 / 94	Gordon	75	1	Northeast	Contributed to initial, local spread
30 / 07– 03 / 08 / 95	Erin	80	1	None	Slight; too far to the North
22–28 / 08 / 95	Jerry	40	Tropical storm	East then West, then Northeast	Main contributor to *Xac* distribution found in late 1995
17–18 / 10 / 96	Lili	85	1	None	Only rain; too far to the SouthSe

Severity category for the storm is on the standardized Saser-Simpson scale for rating hurricanes. Wind direction was dependent on the track of the storm as it passed through or near Miami and the counter-clockwise rotation of the storm.

The measured rainfall in Miami and Fort Lauderdale resulting from tropical storm Jerry was 8.85 and 19.71 inches (22.5 and 50.1 cm), respectively. The final storm on record was Hurricane Lili which traversed Cuba and South of the Florida Keys. Some feeder bands from Lili extended into South Florida and caused local rainstorms in the Miami area. However, it is unlikely that the rainfall associated with Lili caused much more than local increase of citrus canker.

Previously, in relation to citrus bacterial spot disease, tornadoes had been implicated in the introduction of *X axonopodis* pv *citrumelo* into a Florida citrus nursery from the surrounding native vegetation (GRAHAM and GOTTWALD, 1993). During a local 3 January 1996 rain storm, a tornado passed through the citrus canker infected area of Miami on a Southwest to Northeast track. By mid-summer of 1996, numerous infections of citrus canker were found to the North and Northwest of the main infected area. The age of the oldest lesions in the newly infected areas to the North and Northeast was consistent with a January dispersal event. The distribution patterns and age estimations of new infections in late 1996 suggest that *Xac* may have been spread over 6–7 miles (≈9.6–11.2 km) from a single event about this time. In addition, several weather fronts have passed through Miami in 1996. Prevailing winds along the frontal boundaries often pump moisture and winds to the Northeast, which is also consistent with the numerous newly infected sections to the North and Northeast of the most heavily infected sections of Miami.

prognosis

Although considerable manpower, funds, and effort are being aimed at citrus canker eradication in the Miami area, a number of impediments to eradication presently exist. The eradication agency is hampered by the legalities of dealing with thousands of independently owned properties and the reluctance of some residential property owners to allow access to their properties and citrus trees for inspection. Continued northward spread of citrus canker is anticipated due to past and predicted future storm patterns. Continual inadvertent human movement of *Xac* bacteria is probable as there is no way to effectively limit access, traffic, lawn services, and plant movement within such a large residential area. As new infected sections are added to the total infected area, resources for eradication are stretched further and further. When first discovered and delimited by surveys, the Miami epidemic was believed to have been delimited by approximately 14 square miles (≈36 km^2) of residential area. With subsequent spread events, the infested area as of the date of this writing 86 square miles (≈223 km^2). The diligent efforts of the citrus canker survey crews continue to lead to relatively early discovery of new infection. However, the number of

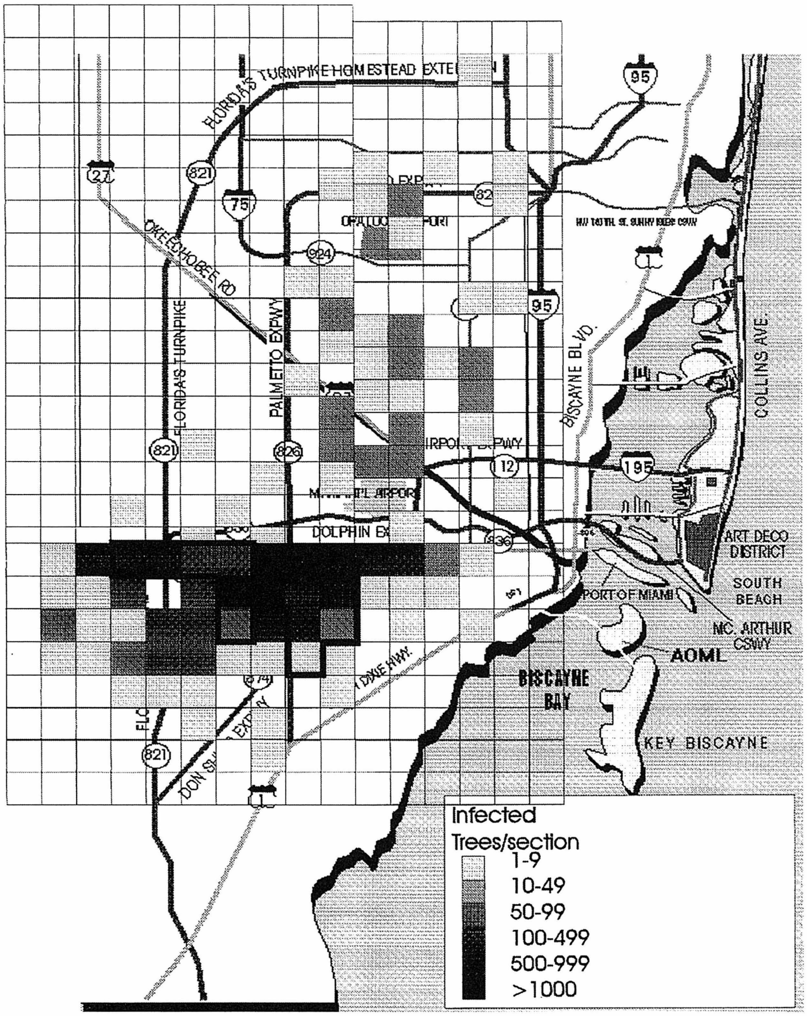

Figure 1
Known citrus canker distribution in the Miami area. Individual gray-scaled squares represent infected areas, each consisting of US Geological Survey sections, 1 square mile in area. The incidence of infection is directly related to the intensity of the color, ie, the darker the square the heavier the infection (See legend insert). Sections bounded by a bold black line represent the extents of the epidemic as first delimited in September 1995.

people that can be dedicated to surveying new areas and eradicating new infection is compromised by the need to reinspect existing infested areas where eradication efforts, ie, tree removal, have occurred, in a continuing effort to catch and remove additional new infections there.

To more effectively delimit the extent of the infected area, the eradication agency has adopted a new survey method which consists of extending its survey several miles outward from the previously delimited infected area. The survey starts on this outer perimeter and works inward toward the foci of infection. Via this method, new infections the farthest from the focus are discovered early and immediately eliminated in an attempt to limit further spread of citrus canker. Simultaneously, the agency continues its efforts of eliminating all known infections from the focus outward. However, bacterial spread resulting from the meteorological events which occurred during the latter part of 1996 will probably go undetected until the spring and summer 1997 flush of susceptible tissue can be examined.

To date, no commercial citrus nurseries or plantations are affected. Unfortunately, even with the best efforts and intentions of the eradication agency, there are no good geographic boundaries to limit the continued spread of citrus canker. Residential citrus forms a loose continuum of susceptible tissues to the North and South of the infected area. Commercial citrus exists to the North, South, and beyond some intervening Everglades West of the infested area. If the canker-infested area continues to expand, commercial citrus-producing areas, as close as 12 miles (≈20 km) to the South and 48 miles (≈80 km) to the North, will be in jeopardy. If the worst case occurs, citrus canker will become firmly established, commercial citrus infected, and eradication efforts must be abandoned. This would not mean the end of citrus production in Florida. Citrus canker is a foliar and fruit disease that at its worst can cause some defoliation, twig die back, fruit blemishes, and fruit drop. A considerable amount of research effort has been directed over recent years at developing citrus canker control strategies which will allow profitable commercial citrus production to continue in the presence of citrus canker (GOTTWALD and TIMMER, 1994). However, some additional production costs associated with disease control can be anticipated, along with numerous trade issues with other citrus-producing states and countries.

addendum

Since the completion of this paper in early 1997, citrus canker has continued to spread in the urban Miami area. As of November 1997, there are 122 sections which have been identified with citrus canker, including two sections in Broward County, which lies North of Dade County, in which Miami is located.

In addition, citrus canker was discovered in the Palmeto area of Manatee County on the west coast of Florida in June 1997. Since that time 47 commercial citrus plantings, consisting of a total of 409 acres, have been identified with the disease. In addition 42 residential properties containing 163 positive trees and a few abandoned commercial grapefruit plantings were also discovered. The majority of citrus canker positive trees and numerous exposed trees in the near vicinity to positive trees have already been destroyed in an attempt to quickly limit the spread of disease in the area.

acknowledgements

We wish to thank Mr Ken Bailey, Mr Richard Gaskella, and Mr Leon Hebb of the Florida Department of Agriculture and Consumer Services, Division of Plant Industry, and Mr John Thomas of the US Department of Agriculture, Animal and Plant Health Inspection Service for information, help, and support in gathering data pertaining to this study.

references

Achor DS, Browning HW, Albrigo LG (1996) Anatomical and histological modifications in citrus leaves caused by larval feeding of citrus leafminer (*Phyllocnistis citrella* Staint). In: *Proc Int Conf Citrus leafminer*, held at Orlando, Florida, April 23-25, 1996. University of Florida, Gainesville, USA, MA Hoy, p 69

Civerolo EL (1984) Bacterial canker disease of citrus. *J Rio Grande Valley Hort Soc* 37,127-146

Gottwald TR, Timmer LW (1994) The efficacy of windbreaks in reducing the spread of citrus canker caused by *Xanthomonas campestris* pv *citri. Trop Agric* 72, 194-201

Gottwald TR, McGuire RG, Garran S (1988) Asiatic citrus canker spatial and temporal spread in simulated new grove situations in Argentina. *Phytopathology* 78, 739-745

Gottwald TR, Timmer LW, McGuire RG (1989) Analysis of disease progress of citrus canker in nurseries in Argentina. *Phytopathology* 79, 1276-1283

Gottwald TR, Graham JH, Egel DS (1992) Analysis of foci of infection of Asiatic citrus canker in a Florida citrus orchard. *Plant Dis* 76, 389-396

Graham JH, Gottwald TR (1992) Research perspectives on eradication of citrus bacterial diseases in Florida. *Plant Dis* 75, 1193-1200

Graham JH, Gottwald TR (1993) Status of citrus bacterial spot in Florida citrus nurseries. In: *Proc IV World Cong Intern Soc Citrus Nurserymen*. South Africa, E Rabe ed, 223-230

Graham JH, Gottwald TR, Browning HW, Achor DS (1996) Citrus leafminer exacerbated the outbreak of Asiatic citrus canker in South Florida. In: *Proc Int Conf Citrus leafminer*, held at Orlando, Florida, April 23–25, 1996. University of Florida, Gainesville, USA, MA Hoy, p 83

Heppner JB (1993) Citrus leafminer: *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae: Phyllocnistinae). *Florida Department of Agriculture and Consumer Services, Division of Plant Industry. Entomology Circular,* No 309

Koizumi M (1977) Relation of temperature to the development of citrus canker in the spring. *Proc Int Soc Citriculture* 3, 924-928

Peltier GL (1920) Influence of temperature and humidity on the growth of *Pseudomonas citri* and its host plants and on infection and development of the disease. *J Agric Res* 20, 447-506

Reedy BC (1984) Incidence of bacterial canker of citrus in relation to weather. *Geobios New Reports* 3, 39-41

Schubert TS, Miller JW, Gabriel DW (1996) Another outbreak of bacterial canker of citrus in Florida. *Plant Dis* 80, 1208

Serizawa S, Inoue K (1975) Studies on citrus canker. III. The influence of wind blowing on infection. *Bull Schizuoka Pref Citrus Exp Sta* 11, 54-67

Serizawa S, Inoue K, Goto M (1969) Studies on citrus canker. I. Dispersal of the citrus canker organism. *Bull Schizuoka Pref Citrus Exp Sta* 8, 81-85

Stall RE, Civerolo EL (1991) Research relating to the recent outbreak of citrus canker in Florida. *Annu Rev Phytopathol* 29, 399-420

Análisis epidemiológico de la propagación del chancro cítrico en la ciudad de Miami, en Florida, e interacción con la minadora asiática de los cítricos.

RESUMEN

HISTORIAL DEL CHANCRO CÍTRICO EN FLORIDA. Tras doce epidemias importantes de chancro cítrico asiático (CCA), debido al *Xanthomonas axonopodis* pv *citri (Xac),* acaecidas del 1986 al 1992 en Florida, se volvía a descubrir la enfermedad, en 1995, en un barrio residencial de Miami. **INTERACCIÓN CON LA MINADORA ASIÁTICA DE LOS CÍTRICOS.** Debido a su comportamiento alimenticio, la minadora asiática de los cítricos, *Phyllocnistis citrella* Stainton, facilita la penetración de la bacteria en las hojas. Esto, ocasiona la formación de grandes cantidades de inóculo que favorecen la diseminación de *Xac* a partir de las salpicaduras de las lluvias. **BÚSQUEDA DE INDICIOS QUE PERMITAN DETERMINAR EL ORIGEN DE LA EPIDEMIA.** Se ha demostrado que la actual epidemia de chancro cítrico de la zona residencial de Miami se halla aquí desde hace 2 ó 3 años; sin embargo, su origen, que se ha revelado diferente del de las epidemias precedentes, sigue siendo desconocido. **ELEMENTOS DE DISPERSIÓN DE UNA EPIDEMIA DE CHANCRO CÍTRICO.** Desde que la enfermedad se halla instalada en un lugar determinado, los elementos más decisivos de su propagación son las salpicaduras de lluvias contaminantes y las tormentas llevadas por el viento y cargadas de inóculo. **EFECTO DE LOS INCIDENTES METEOROLÓGICOS, PASADOS Y PRESENTES, SOBRE LA PROPAGACIÓN.** Los fenómenos meteorológicos individuales, como tormentas, tornados, tempestades tropicales y huracanes habrían contribuido a la dispersión de *Xac* en distancias medianas y grandes del foco de infección. **MEDIDAS QUE HAY QUE TOMAR.** Como, actualmente, muchos factores dificultan la erradicación, se ha adoptado un nuevo método que permite detectar toda infestación alejada del foco y eliminarla en seguida para intentar limitar otras propagaciones del chancro cítrico.

PALABRAS CLAVES

Florida, *Citrus*, necrosis, epidemiología, control de enfermadades.