Xanthomonas axonopodis pv. citri

Introduction

Citrus canker (CC) is an important disease, which reduces yield, disfigures fruit and debilitates trees. Therefore, it can have severe economic impact on the citrus grower, who may be restricted from selling even unblemished fruit from an infected area. Because it is a notifiable disease, its presence in a nursery can cause serious to total loss. For example, some 20 million nursery and young orchard trees were destroyed in Florida in the course of dealing with a flare-up of a closely related disease between 1984 and 1990. Even after the disease is eradicated from an area, nursery operators are faced with continued hardship because of regulations specifying a disease-free period (ca. two years) before normal operations can resume.

In many developing countries, Plant Quarantine Departments suffer from a lack of funds and adequately trained staff, which limit their ability to provide effective services. The Florida experience with CC clearly indicated that even though the cost of prevention is high, the cost of eradication could be infinitely higher.

Identity

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Classification

- Kingdom : Procaryotae
- Phylum : Gracilicutes
- Class : Proteobacteria
- Family : Psedomonadaceae
- Genus : *Xanthomonas*
- Species : *axonopodis* pv. c*itri*
- Synonyms : *Xanthomonas campestris* pv. *citri, Xanthomonas citri, Pseudomonas citri*
- Common names : Canker, chancre bacterien, cancer de los agrios, Bakterienkrebs der Zitrusarten
- Role : Pest

Signs & Symptoms

In nature, CC is manifested in different ways by different strains of the pathogen, *Xanthomonas axonopodis* pv. *citri* (syn. *X. campestris* pv. *citri*). The various strains are distinguished by cultural and physiological characteristics, symptomology, serology, host range, phage sensitivity, fatty acid profiles, repetitive sequence-based PCR, RFLP and AFLP assays of genomic DNA and DNA-DNA homology (Vauterin et al., 2000).

The Asiatic or A strain is the most widespread and damaging form of CC and is the pathogen that appears on plant quarantine (PQ) lists. One recently described variant (strain A*) from south-west Asia restricted to Mexican/W.I. lime, *C. aurantifolia,* contrasts in host range with strain A to which most citrus cultivars and some relatives are susceptible. There are differences in susceptibility among citrus cultivars, with grapefruit, W.I. lime, Palestinian sweet lime, trifoliate orange and its hybrids and Hamlin, Navel and Pineapple sweet oranges being the most susceptible. Only calamondin, citron and kumquat are considered as resistant. Cancrosis B (Strain B), originally described (on

lemon, W.I. lime and pummelo) from Argentina in 1923, spread to Paraguay and Uruguay. The strain causes leaf, shoot and fruit lesions that are smaller than those due to strain A. The bacterium, *X. axonopodis* pv. *aurantifolia*, can be differentiated from strain A by serological and cultural features. Strain B is no longer isolated from infected tissue and is considered to have been displaced by strain A in nature. Cancrosis C (Strain C), also due to *X. axonopodis aurantifolia*, is found only in Brazil and only on W.I. lime, on which it causes symptoms identical to those incited by *X. a.* pv. *citri*.

The first visible symptoms on leaves are small, slightly raised, translucent spots that are darker green than surrounding tissue and appear about 7 days after infection under favourable conditions. They eventually reach a diameter of 2-10 mm, depending on the cultivar and on the age of the tissue when infection took place. The lesions are circular in the early stages but become irregular as they mature. They occur on both sides of the leaf, though more numerous on the under surface and towards the margins (Fig. 1). In wet weather films of bacterial ooze can be seen on the margins of lesions. On leaves, all of the lesions are about the same age and size, since infection is only possible over a short period that the leaf is susceptible. As lesions mature they pass through a colour change from grey to brown, displaying a distinct water-soaked margin surrounded by a yellow halo. They become increasingly corky, with margins higher than the depressed centres. In old lesions the chlorotic halo may disappear. As the disease progresses, defoliation is a common and typical symptom.

The damage caused by CC is invariably more severe when the Asian leaf miner is present. The bacterium invades the feeding galleries made by the miner, which significantly increases the number of lesions and leads to the development of large, irregularly- shaped lesions made up of individual, coalesced lesions. Under such circumstances field resistance breaks down and tolerant varieties become susceptible to infection.

Symptoms on fruit and twigs have the same general appearance as those on the leaves. The lesions on fruit are more variable in size, since the longer period of susceptibility of rind tissue permits several infection cycles of the pathogen to occur. Severely infected trees become defoliated; lack vigour and the fruit fall prematurely or are scarred and deformed (Fig. 2). Chlorotic halos are found on fruit lesions, but do not occur on diseased twigs.

Morphology

Xanthomonas axonopodis pv. *citri* is a Gram negative bacillus (0.4 to 0.7 x 0.7 to 1.8 μm) with a single polar flagellum. It is aerobic and colonies on laboratory media are typically yellow, due to the production of xanthomonadin pigment. If glucose is added, colonies are very mucoid. Isolation from contaminants is facilitated by culturing on a semi-selective medium containing kasugamycin. Optimum growth is at 28-30 C.

Biology & Epidemiology

Host shoots and leaves are susceptible up to 6 weeks after the flush is initiated. On the other hand, fruit remain susceptible for 90 days after petal fall. Infections occurring after the period of susceptibility produce inconspicuous lesions due to increased thickness of the cuticle. However, infection of mature tissues can occur through wounds, e.g., pruning, leaf miner. The availability of young shoots during wet weather is conducive to the infection process. Thus, young trees (which tend to flush more frequently) and trees on vigorous rootstocks are more at risk and have higher levels of disease. *X. axonopodis*

pv. *citri* perennates/overwinters in lesions that develop from infections late in the season. It has been demonstrated that bacteria can remain viable in stem lesions for about 7 years. The pathogen does not survive on fallen fruit or leaves for more than 2 months.
Inoculum early in the year comes from lesions exuding bacteria in humid, wet weather. The major sources of inoculum are the angular shoots. The pathogen is disseminated by rain splash of the exuded bacteria, often aided by wind. By this means, it moves within individual trees or to neighbouring trees. Meteoric rain, i.e., rain driven by storms, hurricanes etc., disseminates over longer distances of up to several miles. However, the pathogen spreads from one country to another on planting material – budwood, rootstock seedlings (the mode of entry into Florida in 1910) or on nursery trees. In common with many other bacterial pathogens, possible modes of dissemination include contaminated clothing and hands of workers, contaminated equipment, field boxes and discarded fruit. Inconspicuous lesions on fruit shipped commercially may disseminate the bacterium over long distances – one of the reasons for imposing quarantines on fruit movement out of infected areas.
Bacteria enter the plant through either wounds or stomata. Wind-blown inoculum is forced through the stomata of turgid leaves and directly into mesophyll cells. In warm conditions, (20-30 C) lesions develop in 7 days, thereby generating new inoculum within a short time.

Dispersal / Vectors

Over short distances, the disease is spread by wind and rain. It is transmitted by fruit, nursery plants and budwood, contaminated equipment, clothing and field boxes.

Management

Quarantine/Eradication
Citrus canker is one of a relatively small number of diseases against which exclusion and eradication programmes have been successful. Citrus canker does not exist in Europe or in several countries around the world where the pathogen would be expected to thrive. The chief strategy leading to successful exclusion is the imposition of strict regulations prohibiting the importation of propagating materials (budwood, plants) and fruit (whether commercial or not) from areas or countries where the bacterium exists.
A public education programme is an essential part of the regulatory action.
As mentioned earlier, campaigns in Australia, New Zealand and South Africa have eliminated CC. Upon the detection of CC in an area, regulatory action is based partly on the length of time the disease has been active. The latter can be estimated by the number of infected trees and by the age of the lesions on a given tree. Since the period of leaf susceptibility is known, the age of lesions can be estimated. When symptoms are observed only on the latest flush, it can be assumed the disease was initiated some few weeks or months earlier. Based on the 60-90 day susceptibility period of fruit, the age of fruit lesions can be calculated from knowledge of the date of blooming. Lesions on twigs do not usually develop until fruit and leaves have experienced one or two infection cycles.

Where canker is endemic, a number of cultural practices help to reduce the level of infection:

- The establishment of windbreaks to reduce the dissemination of inoculum.

- Encouraging vegetation to grow between rows to reduce the injury of leaves by wind-blown sand.
- Avoid operations in groves when trees are wet to reduce dissemination of inoculum.
- Instituting control measures of the Asian citrus leaf miner especially on young trees and on trees prone to frequent flushing.
- Applying copper fungicides based on disease forecasting, to protect fruit for the 3-month period after petal fall; grapefruit may require more fungicide cycles.
- Pruning infected shoots.
- Limiting scion choices to more tolerant cultivars such as; Valencia orange or Satsuma mandarin.

Host Notes

All citrus cultivars, citrus hybrids, some citrus relatives

Distribution

The earliest records of CC (ca. 1840s) came from Southeast Asia, where it is considered to be endemic. From there it has spread to Asia (China, Japan, Taiwan, Sri Lanka, the Philippines), Africa (Republic of Congo, Mozambique) islands in the Pacific and Indian Oceans, South America (Brazil, Argentina, Uruguay) and the USA (Florida, Gulf Coast). The disease has been eradicated from Australia, South Africa, Fiji Islands, Mozambique, New Zealand and the Gulf States of the USA. So far, it has not been reported from Europe.

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Web Resources: -

http://www.ceris.purdue.edu/napis/a-facts/citrus.html
http://www.ecoport.org/EP.exe$EntNameSrc
http://www.aphis.usda.gov/ppq/ep/citrus/

Fig. 1: Citrus canker lesions on grapefruit leaf, showing water-soaked zone around infected area.
Photo by Nelson Gimeses Fernandes

Fig. 2: Citrus canker on grapefruit.