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FIELD IDENTIFICATION, ERADICATION AND CURRENT MANAGEMENT OF CITRUS CANKER CAUSED BY *XANTHOMONAS CAMPESTRIS* PV. *CITRI* IN SATPURA PLATUN OF MADHYA PRADESH, INDIA

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Abstract

Citrus canker disease caused by *Xanthomonas campestris* pv, *citri* is reported on lime in the present study for the Satpura Platun of Madhya Pradesh at Chhindwara district. The disease was found two block of Chhindwara district on lime in 20 orchards during 2012-2016. The basic facts about the citrus canker disease cycle are well known. Leaf infections occur through stomata and wounds. Leaves are most susceptible when expanded between 50 and 80%. Rain wets disease lesions on citrus fruits, twigs, and leaves, allowing the bacteria to ooze to the plant tissue surfaceSevere infection of the disease produce a variety of effects including defoliation, dieback, severely blemished fruit, reduced fruit quality and premature fruit drop. Warm, humid, cloudy climate, along with heavy rainfall and strong wind promotes the disease.Copper hydroxide was significantly superior to all other treatments in decreasing the incidence of citrus canker disease that developed on inoculated lime seedlings. Streptocycline, copper oxychloride and Bordeaux mixture were effective in reducing the incidence of the disease.

Key words : Citrus canker, *Xanthomonas axonopodis* pv. *Citri*, symptoms, pathogenicity, host range, disease management.

Introduction

Citrus canker is a contagious disease of citrus (and some other plant species of the Rutaceae family) caused by the bacteria *Xanthomonas axonopodis* pathovar *citri*. Infected trees display unsightly lesions, which can form on leaves, fruit and stems. Trees infected with the disease may suffer from low vigour and a reduction in fruit quality and quantity. Citrus canker is a serious disease impacting on citrus production and is the subject of a number of control and eradication programs around the world. While not harmful to humans, canker significantly affects the vitality of citrus trees, causing leaves and fruit to drop prematurely; a fruit infected with canker is safe to eat, but too unsightly to be sold. The disease, which is believed to have originated in Southeast Asia, is extremely persistent when it becomes established in an area. Citrus groves have been destroyed in attempts to eradicate the disease. There is no cure for citrus canker. Prevention is the best option to protect against citrus canker. Canker causes the citrus tree to continually decline in health and fruit production until the tree produces no fruit at all. Citrus canker is highly contagious and can be spread rapidly by Wind-driven rain, lawnmowers and other landscaping or farm equipment, people carrying the infection on their hands, clothing or equipment, moving infected or exposed plants or plant parts (fruit, leaves or stems).

Symptoms and signs

Citrus canker can be a serious disease where rainfall and warm temperatures are frequent during periods of shoot emergence and early fruit development. This is especially the case where tropical storms are prevalent. Citrus canker is mostly a leaf-spotting and fruit rind-blemishing disease, but when conditions are highly favorable for infection, infections cause defoliation, shoot dieback, and fruit drop.

Leaf lesions : Citrus canker lesions start as pinpoint spots and attain a maximum size of 2 to 10 mm diameter

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the eventual size of the lesions depends mainly on the age of the host tissue at the time of infection and on the citrus cultivar. Lesions become visible about 7 to 10 days after infection on the underside of leaves and soon thereafter on the upper surface. The young lesions are raised or 'pustular' on both surfaces of the leaf, but particularly on the lower leaf surface. The pustules eventually become corky and crateriform with a raised margin and sunken center. A characteristic symptom of the disease on leaves is the yellow halo that surrounds lesions. A more reliable diagnostic symptom of citrus canker is the water-soaked margin that develops around the necrotic tissue, which is easily detected with transmitted light.

Fruit and stem lesions : Citrus canker lesions on fruit and stems extend to 1 mm in depth and are superficially similar to those on leaves. On fruit, the lesions can vary in size because the rind is susceptible for a longer time than for leaves and more than one infection cycle can occur. Infection of fruit may cause premature fruit drop but if the fruit remain on the tree until maturity such fruit have reduced fresh fruit marketability. Usually the internal quality of fruit is not affected, but occasionally individual lesions penetrate the rind deeply enough to expose the interior of the fruit to secondary infection by decay organisms. On stems, lesions can remain viable for several seasons. Thus, stem lesions can support long-term survival of the bacteria.

Leafminer interaction : The Asian leafminer (*Phyllocnistis citrella*) can infest leaves, stems, and fruit and greatly increase the number of individual lesions which quickly coalesce and form large irregular shaped lesions that follow the outlines of the feeding galleries. Leafminers feed on the epidermis just below the leaf cuticle. Numerous cracks occur in the cuticle covering leafminer galleries providing means for bacteria to penetrate directly into the palisade parenchyma and spongy mesophyll which are highly susceptible to infection. Citrus foliar wounds normally callus within 1-2 days, however, the extensive wounds composed of the entire leafminer feeding galleries do not callus for 10-12 days, greatly extending the period of susceptibility of galleries to infection. Leafminer infestations can be very prevalent and severe producing hundreds, if not thousands of potential infection courts on individual trees. When bacterial dispersal events occur in the presence of the leafminer, not only is inoculum production greatly exacerbated, but so is the potential for infection over the entire dispersal range.

Disease cycle : *Xanthomonas axonopodis* pv. *citri* overseason in infected area, which is canker lesion on leaf or stem. The bacteria ooze out of the lesions when there is free moisture. During the rainy weather, wind-blown rain carries the inoculum to the new susceptible hosts. The bacteria infect new plants through stomata and wounds. The wound can be caused by pruning or hedging that could cut open mesophyll tissues for direct infection. The rain can also cause water congestion on leaf surface, form column of water through stomata and promote infection through the natural opening. The infection can form on fruit, foliage and young stem. The varied size of lesions on citrus fruit is because of the multiple cycles of infections.

Pathogenicity : *Xanthomonas axonopodis* has the capability to form a biofilm for attachment on the host. The biofilm is the result of the production of extracellular polysaccharides (xanthan). The biofilm ensures the virulence and epiphytic survival of *X. axonopodis* pv. *citri* prior to the development of citrus canker. In addition, the bacteria secrete transcriptional activator-like (TAL) effectors through type III secretion system. The effector interacts with host machinery to induce transcription for genes that regulate plant hormones such as gibberellin and auxin.

Host range : Among citrus cultivars and rootstocks, citrus canker is most severe on grapefruit some sweet oranges such as Hamlin, Pineapple, and Navel and lemons and trifoliate orange [*Poncirus trifoliata* (L.)] and their hybrids that are used for rootstocks (table 1).

Disease management

Exclusion : The first line of defense against citrus canker is exclusion. Citrus canker still does not exist in some countries or regions of countries where climatic conditions are favorable for pathogen establishment, which is probably because of rigid restrictions on the importation of propagating material and fruit from areas with canker. Unfortunately, with increased international travel and trade, the likelihood of *X. axonopodis* pv. *citri* introduction is on the rise as it is with many exotic pests and pathogens. Documentations of 6 separate introductions of citrus canker into India have occurred since 1985, demonstrating that even with eradication, reintroduction is a continual process and problem.

Sanitation : Numerous cases of new infections of citrus canker are linked to human and mechanical transmission. Humans can carry bacteria on their skin, clothing, gloves, hand tools, picking sacks, ladders, etc. Vehicles can become contaminated by brushing wet foliage or coming in contact with plant material. Machinery such as tractors, implements, sprayers,

Table 1 : Relative susceptibility/resistance to citrus canker of commercial citrus cultivars and species.

Rating	Citrus cultivars
Highly resistant	Calamondin (*C. mitus*); Kumquats (*Fortunella* spp.)
Resistant	Mandarins (*C. reticulata*) – Ponkan, Satsuma, Tankan, Satsuma, Cleopatra, Sunki, Sun Chu Sha
Less susceptible	Tangerines, Tangors, Tangelos (*C. reticulata* hybrids); Cravo, Dancy, Emperor, Fallglo Fairchild, Fremont, Clementina, Kara, King Lee, Murcott, Nova, Minneola, Osceola, Ortanique, Page, Robinson, Sunburst, Temple, Umatilla, Willowleaf (all selections); Sweet oranges (*C. sinenesis*) – Berna, Cadenera, Coco, Folha Murcha, IAPAR 73, Jaffa, Moro, Lima, Midsweet, Sunstar, Gardner, Natal, Navelina, Pera, Ruby Blood, Sanguinello, Salustiana, Shamouti, Temprana and Valencia; Sour oranges (*C. aurantium*)
Susceptible	Sweet oranges - Hamlin, Marrs, Navels (all selections), Parson Brown, Pineapple, Piralima, Ruby, Seleta Vermelha (Earlygold), Tarocco, Westin; Tangerines, Tangelos – Clementine, Orlando, Natsudaidai, Pummelo (*C. grandis*); Limes (*C. latifolia*) – Tahiti lime, Palestine sweet lime; Trifoliate orange (*Poncirus trifoliata*); Citranges/Citrumelos (*P. trifoliata* hybrids)
Highly susceptible	Grapefruit (*C. paradisi*); Mexican/Key lime (*C. aurantiifolia*); Lemons (*C. limon*) and Pointed leaf Hystrix (*C. hystrix*).

Table 2 : Control schedule for Citrus Canker.

Before monsoon	
1st Week of June	Pruning of infected twings
2nd Week of June	Spray copper oxychloride (COC 0.3%)
During / after monsoon	
1st Week of July	Spray COC 0.3% or Streptocycline 100 ppm
1st Week of August	———— Do————
1st Week of September	———— Do————
1st Week of November	———— Do————

hedgers, etc. can similarly become contaminated and even inadvertently transport plant parts. In areas, where citrus canker is resident, it is necessary to construct decontamination stations for personnel, vehicles and machinery, which are sprayed with bactericidal compounds.

Eradication : Once introduced into an area, elimination of inoculum by removal and destruction of infected and exposed trees is the most accepted form of eradication. To accomplish this, trees may be uprooted and burned or in urban areas, cut down and chipped and the refuse disposed of in a landfill. In India, state law requires that all citrus trees within 579 m (1900 ft) of infected trees must be removed in both residential and commercial situations.

Disease management : In countries, where the disease is well established and severe, only the more resistant types of citrus, such as Valencia oranges and mandarins may be profitable. In regions where canker is endemic, certain cultural practices are used to reduce the severity of the disease. It is imperative to avoid working in infected orchards when the trees are wet from dew or rain. The reduction of wind is another primary concern. Wind speeds are reduced by deployment of windbreaks on the perimeter of the orchard or between the rows. Reduction of wind speed lowers the probability of direct penetration of stomates by bacteria as well as entry of wind-induced injuries on foliage and fruit. Where canker is a major problem, control requires integration of appropriate cultural practices including sanitation, windbreaks and leafminer control with frequent applications of copper sprays. Copper sprays have been shown to reduce infection somewhat. Because the fruit is susceptible to canker during the first 90 days after petal fall, it is important to maintain a protective coating of a copper material on the fruit surface during this period. Two or three treatments may be needed for this purpose, depending on rainfall and cultivar susceptibility. Windbreaks can greatly reduce spread and severity of disease and increase the efficacy of copper sprays. Leafminer control is particularly important on young trees and certain cultivars that have a high proportion and greater frequency of vegetative growth flushes.

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