Citrus canker is a disease affecting citrus species that is caused by the bacterium Xanthomonas axonopodis. Infection causes lesions on the leaves, stems, and fruit of citrus trees, including lime, oranges, and grapefruit. 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 South East Asia, is extremely persistent when it becomes established in an area. Citrus orchards have been destroyed in attempts to eradicate the disease. Australia, Brazil and the United States are currently suffering from canker outbreaks.

**Pathology**

Plants infected with citrus canker have characteristic lesions on leaves, stems, and fruit with raised, brown, water-soaked margins, usually with a yellow halo or ring effect around the lesion. Older lesions have a corky appearance, still in many cases retaining the halo effect. The bacterium propagates in lesions in leaves, stems, and fruit. The lesions ooze bacterial cells that, when dispersed by windblown rain, can spread to other plants in the area. Infection may spread further by hurricanes. The disease can also be spread by from contaminated equipment, and by transport of infected or apparently healthy plants. Due to latency of the disease, a plant may appear to be healthy, but actually be infected.

Citrus canker bacteria can enter through a plant's stomata or through wounds on leaves or other green parts. In most cases, younger leaves are considered to be the most susceptible. Also, damage caused by Citrus Leaf Miner larvae (Phyllocnistis citrella) can be sites for infection to occur. Within a controlled laboratory setting, symptoms can appear in 14 days following inoculation into a susceptible host. In the field environment, the time for symptoms to appear and be clearly discernible from other foliar diseases varies; it may be on the order of several months after infection. Lower temperature increases the latency of the disease. Citrus canker bacteria can stay viable in old lesions and other plant surfaces for several months.
Citrus Leprosis

Leprosis is a virus-induced disease causing chlorotic lesions on citrus leaves, fruit, and twigs. Leprosis is currently a highly important citrus disease in Brazil and other areas of South America. A new outbreak of leprosis has recently been reported in Panama. Prior to 1925, leprosis was once a serious disease of citrus in Florida, but it has not been observed here since. The causal agent of leprosis is transmitted by several species of Brevipalpus mites. It is not known why leprosis disappeared in Florida. Improved mite control procedures may have been at least partly responsible for the disappearance of the disease from Florida. A great deal of uncertainty exists about the epidemiology of leprosis and its potential to reappear in Florida.

The causal agent of leprosis is a naked bullet-shaped virus that has recently been molecularly characterized. Two different types of leprosis viruses exist. One virus occurs in the cytoplasm and the other resides primarily in the nucleus of infected cells.

Citrus Chlorotic Dwarf

Citrus chlorotic dwarf (CCD) is a viral disease of citrus that was first found in Eastern Turkey in 1986 (Fig. 1). The disease was found not long after the accidental introduction of the bayberry whitefly into Eastern Turkey. Recent research has confirmed that the causal agent of the disease is transmitted by the bayberry whitefly.

The disease is known to affect lemon, mandarin, grapefruit and sweet oranges although sweet oranges are less affected than the others. The disease is considered to be the most serious citrus disease in the Eastern Mediterranean and has spread rapidly throughout the citrus growing regions of Turkey wherever the vector was present.

The virus that causes this disease can be graft-transmitted, but it is not mechanically transmissible.
Graft inoculation to rough lemon is the only detection method available at this time. It can take several months for the symptoms to manifest on the inoculated host plant. The virus can be eliminated from infected budwood by shoot tip grafting.

Citrus Greening

Citrus greening is also known by its Asia name of huanglongbing, or yellow dragon disease. It is a bacterial disease that attacks the vascular system of plants. Once infected, there is no cure for a tree with citrus greening disease. In areas of the world where citrus greening is found, citrus trees decline and die within a few years. This deadly disease does not affect humans or animals, only certain plants.

The bacteria are usually transmitted by insects known as citrus psyllids. In June 1998, the insect that carries the Asian strain of citrus greening (Diaphorina citri) was found for the first time in the US in Delray Beach; the inspector found no citrus greening infection at that time.

Because of the extreme threat to Florida citrus, the Department of Agriculture has been conducting a citrus greening survey for many years. Once the Asian citrus psyllid was discovered here, citrus greening survey efforts were intensified. A survey in June 2000 found two Okeechobee nurseries had plants with this insect.

State and federal officials have again intensified the survey to identify how far this disease has spread. Experts from the University of Florida and state and federal agricultural officials are quickly mobilizing to combat this threat to our agricultural industry.

Symptoms of citrus greening disease look like plants with severe nutritional deficiencies: yellow shoots, twig dieback, tree decline and reduced fruit size and quality. Often only a single branch is affected at first. Older leaves develop patches of discoloration as shown in the attached photos. The inside of the fruit is lopsided and is inedible due to poor taste. The fruit will drop off before ripening and has poor color.
Citrus Variegated Chlorosis

Citrus Variegated Chlorosis first appeared in Brazil in 1987 and has rapidly become one of the most economically important diseases affecting sweet orange production in Brazil. Citrus Variegated Chlorosis has become widespread in most major citrus growing areas through movement of infected nursery stock due to lack of certification programs and high Citrus Variegated Chlorosis infection rates in Brazil. Losses due to Citrus Variegated Chlorosis are now estimated to exceed several million dollars per year in Brazil. Citrus Variegated Chlorosis also has been reported in Argentina and Paraguay, but has not been found outside of South America. The causal agent of Citrus Variegated Chlorosis is vectored by sharpshooter leafhoppers (Figure 1). Sharpshooters feed on plant xylem (Xylem conducts water within the plant) and acquire the Citrus Variegated Chlorosis causal agent during feeding, and then spread the pathogen when they move and feed on a new plant. Some of these sharpshooters are already established in Florida. Citrus cultivars grown in Florida are all susceptible to Citrus Variegated Chlorosis. Climatic conditions in Florida are favorable for the occurrence and establishment of the disease. It appears that if introduced, Citrus Variegated Chlorosis has the potential to become a significant problem for Florida citrus production.

Causal Agent of Citrus Variegated Chlorosis

Citrus Variegated Chlorosis is caused by the xylem-inhabiting bacterium Xylella fastidiosa. Similar strains of X. fastidiosa cause Pierce's disease of grape, phony peach, and leaf scorch diseases of almond, coffee, oak, plum and sycamore. These strains can be distinguished by host range and other physiological characteristics. The exact origin of the Citrus Variegated Chlorosis pathogen is unknown, but it could likely have been transmitted into citrus from another host by sharpshooter vectors and from that point has continued to spread by propagation and insect vectors. Studies have shown that the Citrus Variegated Chlorosis strain is apparently closely related to the bacterium causing coffee leaf scorch, and inoculation of coffee with the Citrus Variegated Chlorosis bacterium causes coffee leaf scorch symptoms. The Citrus Variegated Chlorosis pathogen has been the subject of intensive research in Brazil and its genome has recently been completely sequenced.
Sweet Orange Scab

Sweet orange scab, caused by the fungus *Elsinoe australis* Bitancourt & Jenkins, is a serious foreign threat to Florida's production of sweet oranges, mandarins, and lemons for the fresh market. The disease was first reported from Paraguay in 1882. It has since been found in Argentina, Brazil, Bolivia, and Uruguay in South America, as well as in New Caledonia, Eritrea, and Sicily.

On young fruit, the pathogen causes deformation of the rind, which becomes protuberant or swollen where the lesions occur. The deformations gradually disappear as the fruit enlarges, and the mature fruit has the normal spherical shape. Individual lesions are pustules of corky tissue which are round to irregular, slightly raised, and usually slightly convex, measuring 2-6 mm in diameter. Larger lesions are more flattened and may be traversed by more or less deep furrows which result from the rupture of corky tissues. In some cases, a circular fissure surrounds the central part of the lesion, and this part may be detached with comparative ease, leaving a slightly depressed scar covered with a silvery pellicle.

The corky tissues are buff-colored, sometimes with a reddish tinge which is also noted in the rind surrounding the lesions. The conidial pustules of the causal fungus are often visible near the center of the lesion and are buff to brown or black.

Sweet orange scab rarely occurs on leaves, but if it does, the pustules are located on the lower surface clustered along the midrib and seldom form protuberant outgrowths as on the fruit. They are smooth and frequently have a somewhat glossy surface. Lesions are usually less than 2 mm in diameter. Scab is also rare on twigs, but when they occur, lesions resemble those on leaves.
Witches' Broom Disease of Lime

Witches' broom disease is a very serious disease of acid (Mexican) limes. The disease first appeared in Oman around 1975 and has spread extensively there. It is estimated that over 98% of limes currently grown in Oman are infected with Witches' Broom Disease of Lime. Witches' Broom Disease of Lime kills lime trees in less than 5 years and has become a major limiting factor for lime production in Oman. Witches' Broom Disease of Lime later appeared in the United Arab Emirates (UAE) and has recently been found in Iran. It has been reported recently in India, but it is not yet clear if the causal agent is the same. Presumably, Witches' Broom Disease of Lime poses greater risks in arid areas such as California with a climate similar to that in Oman and UAE. Witches' Broom Disease of Lime appears unlikely to pose a severe economic threat to Florida because our major scion cultivars are not susceptible. However, establishment of Witches' Broom Disease of Lime in susceptible cultivars is conceivable in Florida.

The Causal Agent of Witches' Broom Disease of Lime

Witches' Broom Disease of Lime is caused by a phytoplasma (a prokaryote lacking cell walls; formerly called mycoplasma-like agent) that is designated as Candidatus Phytoplasma aurantifolia (Figure 1). The Witches' Broom Disease of Lime agent can be observed in high concentrations in the phloem of infected plants by electron microscopy and is apparently closely related to sun hemp and sesamum phyllody phytoplasmas.

Typical Symptoms

The first symptoms of Witches' Broom Disease of Lime in the field are one or more witches' brooms of thin proliferating twigs that have small, pale leaves (Figure 2). Additional witches' brooms appear as the disease progresses and extensive die-back occurs (Figure 3). Trees die within 3-5 years. Symptoms may appear within 6 months in graft-inoculated plants and warm conditions favor symptom expression.

How Is it Transmitted?

Field observations suggest that extensive natural spread of Witches' Broom Disease of Lime has occurred in Oman and UAE, but it is uncertain if this is from citrus to citrus or
from other hosts. It is suspected that a non-citrus host reservoir for the causal agent exists and may be the original source of infection. Transmission by a leafhopper (Hishimonus phycitis) that is common on citrus in Oman, UAE, and Iran is suspected, but has not been confirmed experimentally. The Witches' Broom Disease of Lime phytoplasma can be found in leafhoppers collected from infected citrus trees. Witches' broom also can be graft-transmitted using tissue from witches' broom shoots as well as transmitted experimentally via dodder between citrus and periwinkle. A recent report indicates that Witches' Broom Disease of Lime phytoplasma can be seed-transmitted based on PCR tests, but needs further examination. More information on insect vectors and non-citrus hosts are needed to establish effective quarantines and to predict the potential spread if introduced.

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Citrus Black Spot

Citrus black spot is one of the most important fungal diseases of citrus worldwide. The symptoms are necrotic lesions on fruit that make them unacceptable for fresh market. When disease is severe, black spot may cause extensive premature fruit drop that reduces yields of fruit for processing. Thus, citrus black spot must be controlled to achieve profitable production. Citrus black spot has been a significant production problem in a number of countries in Southeast Asia, Africa, South America, and in Australia. Although citrus black spot has not been reported in the U. S., climatic conditions in Florida are likely favorable for the occurrence and establishment of black spot disease. Citrus cultivars grown in Florida are also vulnerable to damage by black spot. Citrus black spot could be introduced to the U. S. via movement of infected fruit or illegal introduction of vegetative plant materials.

Causal Agent

Citrus black spot is caused by a fungus whose imperfect (asexual) stage is called Phyllosticta citricarpa, and whose perfect (sexual) stage is called Guignardia citricarpa. G. citricarpa is limited to citrus as far as is known. G. mangiferae, a related species, is a common saprophyte that has been isolated from numerous plants including almonds, avocados, guavas, mangoes, passionfruit, and a variety of ornamentals. G. mangiferae is widespread in Florida. Isolation of G. mangiferae from citrus fruit spots has periodically caused confusion when a diagnosis of citrus black spot was based on fungal morphology in culture without testing pathogenicity.
Typical Symptoms
G. citricarpa causes cosmetic lesions on the rind of fruit that are the most conspicuous symptom of infection. Fruit symptoms can be quite variable. Black spot lesions begin as small orange or red spots with black margins and enlarge to become necrotic lesions. Green tissue may surround the black lesions. At least four types of lesions have been described. Hard spot lesions and virulent spot are the most conspicuous. Speckled blotch or false melanose spots (Fig. 3) appear on green fruit. Freckle spots become more pronounced late in the season or during storage. Black pycnidia, which are the asexual reproductive units of the fungus, may be present in all types but speckled blotch. G. citricarpa may also cause leaf spots, particularly on lemons, but these are usually not conspicuous (Fig. 4). High temperature, high light intensity and stress all favor symptom expression.