DISEASES CAUSED BY PHYTOPLASMAS

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Phytoplasmas (previously referred to as mycoplasma-like-organisms, MLO) are cellular parasites recognized as causing diseases in many crops. Although phytoplasmas are graft transmissible and cause symptoms similar to those typically associated with infection by a virus, they are actually bacteria-like microorganisms; similar to bacteria, remission of the disease symptoms they cause can be achieved experimentally by injecting the antibiotic tetracycline.

PEACH DISEASES CAUSED BY PHYTOPLASMAS

Peach rosette, peach yellows, little peach, and red suture are reported in peach orchards of the Southeast. However, except for peach rosette, they occur infrequently. Peach yellows disease was first observed in 1791 in Pennsylvania, rosette in 1891 in Georgia, while little peach and red suture were first seen in 1896 and 1911, respectively, in Michigan. Other diseases of peach associated with infection by phytoplasmas occur in other areas of the United States and the world. Peach yellow leaf roll, caused by the western-X phytoplasma, occurs in California. X-disease occurs in the northern United States and Canada. Although peach rosette, peach yellows, little peach, and red suture are distinct diseases, they are all caused by phytoplasmas that are very closely related to the western-X phytoplasma. In Europe, the stone fruit yellows phytoplasma (a species distinct from western-X) causes disease(s) in *Prunus*.

CHARACTERISTICS OF DISEASES CAUSED BY PHYTOPLASMAS

Phytoplasmas typically cause abnormalities in growth (rosetting, willowy growth, yellowing) that may be confused with symptoms of infection by a virus, and tests to confirm the presence of a phytoplasma are therefore necessary. Unlike typical bacteria, phytoplasmas cannot be cultured on artificial media in the laboratory. However, they can be detected under the light microscope using phytoplasma-specific stains such as DAPI and Dienes' stain, and they display a characteristic morphology when thin sections of phloem cells are examined in the electron microscope. Enzyme-linked immunosorbent assay (ELISA) and molecular techniques, including DNA probes and polymerase chain reaction (PCR), are also used to detect phytoplasmas. Symptom remission following experimental treatment with antibiotics is strong evidence that phytoplasmas are involved in the disease syndrome. However, several weeks of treatment may be necessary before remission of symptoms is observed.

The transmission of phytoplasmas from plant to plant is usually dependent upon insect vectors. Other means of in-orchard transmission, such as root grafting and parasitic weeds, are of minor importance. Unfortunately, propagation from a symptomless, but infected, tree will ensure almost 100% transmission of phytoplasmas to progeny trees. As with plant viruses, it is prudent to visually check blocks used for cutting budwood for symptoms. If orchards with suspicious trees are used, individual trees used for budwood should be checked for phytoplasmas when they are checked for viruses. No transmission through seed is known. The insect vectors are leafhoppers, psyllids, and planthoppers. Vectors acquire phytoplasmas by feeding on an infected plant. After a latent period (days to weeks), during which the phytoplasma multiplies in the insect, it becomes able to transmit the microorganism to other plants during feeding. Nymphal stages of the vector acquire the phytoplasma more readily than adults, and the microorganism is retained through all subsequent developmental stages. Phytoplasmas are not transmitted through the insect's eggs.

PEACH ROSETTE

Peach rosette (Figure 1A) is characterized by a lack of shoot elongation with dormant buds producing a compacted growth habit somewhat reminiscent of the basal rosettes seen in some herbaceous biennials and perennials. Shortened internodes result in a large number of leaves over a very short distance. Leaves are small in size and initially dark or normal green, then later turn yellow (Figure 1B). Normally, dormant buds break and produce rosettes. Fruit usually falls before maturity. The disease can kill a tree in a few months. When only one or two scaffold limbs are affected, two years may elapse before tree death. Specific vector species of peach rosette are unknown. Natural spread does occur.

Figure 1. *Peach rosette*. (A) Compact growth with many leaves typical of rosette. (B) Trees infected with rosette are often yellower than non infected trees. The tree on the left is displaying rosette and has no fruit, while the tree on the right shows no sign of rosette and is carrying a normal fruit load.

PEACH YELLOWS

Peach yellows (Figure 2A, B) is first recognized by off-color, yellowing trees. Leaves near tips of young branches show vein clearing. The newest expanding leaves are sickle-shaped instead of being in their normal upright position. Frequently only one or two branches are affected. After the disease becomes well established, many thin, upright shoots are apparent along affected branches. Typically, fruit on affected trees or branches ripens prematurely. The disease is lethal in two to five years. Natural spread does occur in the Southeast.

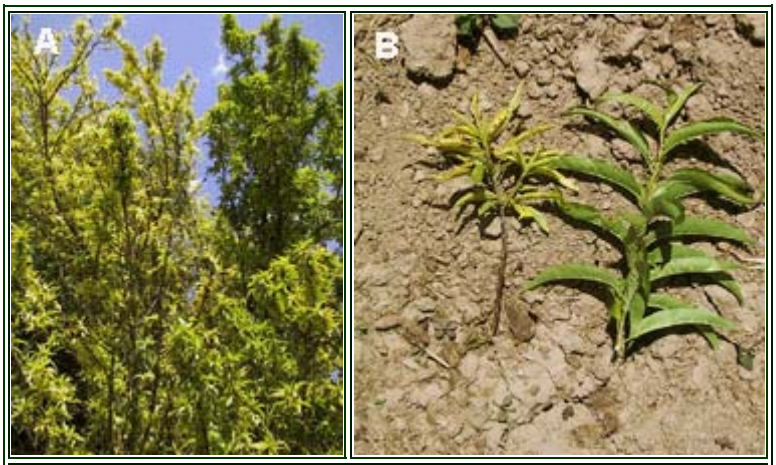

Figure 2. *Peach yellows*. (A) A tree showing both small yellowy growth of yellows and normal growth. (B) The branch on the left shows yellow growth as compared with the one on the right. Image by Eric Boa, CABI Bioscience.

LITTLE PEACH

Little peach symptoms (Figure 3) may resemble some aspects of the symptoms of yellows and rosette and, like rosette and yellows, only one or two branches of whole trees may be affected. Apical dominance is lost and all buds on an infected limb develop thin, willowy shoots with small leaves. The shoots are longer than on rosette-affected trees but shorter than on yellows-affected trees. Shoots are upright in growth habits as with yellows-affected trees. No fruit is produced on limbs displaying little peach symptoms. Fruit maturity

is delayed and fruit is smaller than normal. Death occurs several years after symptoms appear. The vector(s) of little peach is unknown.

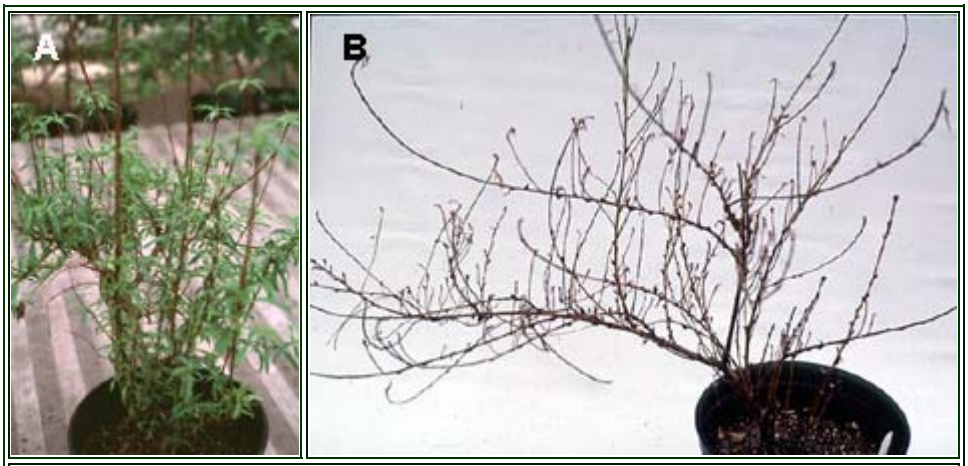

Figure 3. *Little peach*. (A) A seedling tree with the prolific, willowy growth typical of little peach. The leaves are usually much smaller than normal. (B) The contrast between growth in infected trees and normal trees is most noticeable in dormant trees.

RED SUTURE

Red suture (Figure 4) may appear as a dark red suture on fruit that ripens prematurely, with the flesh in the suture soft and watery. In other instances, a prominent red suture that softens is observed on an otherwise green fruit. The tree, except for fruit, is symptomless at this point. After several years, an infected tree or branch may have symptoms similar to little peach-affected trees. An infected tree may survive for a number of years, but the fruit is inedible. The vector(s) of red suture is unknown.

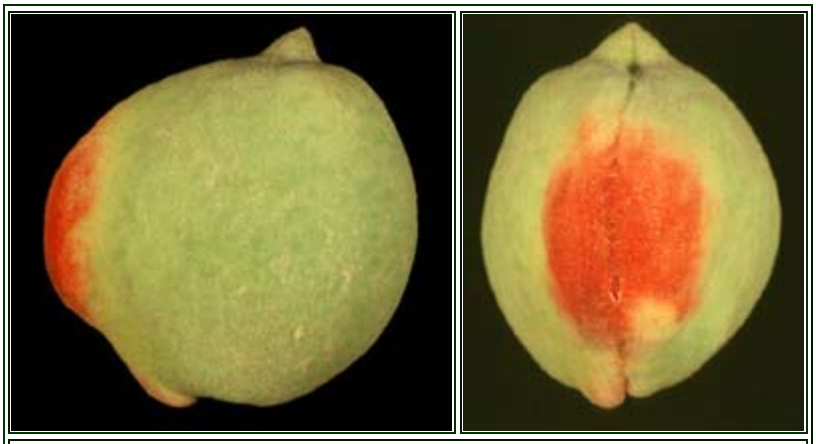

Figure 4. *Red suture*. Two views of an immature fruit showing the prominent suture and premature reddening around the suture typical of the disease. In some instances, the red area may soften well before the remainder of the fruit is ripe.

OCCURRENCE AND SPREAD OF PHYTOPLASMAS

Phytoplasma-associated diseases typically infect only a few trees within an orchard. Historically, infections of peach yellows reached epidemic proportions in the late nineteenth and early twentieth centuries. More recently (late 1970s), an unprecedented epidemic of peach yellow leaf roll occurred in northern California. No specific insect species has been identified as transmitting peach rosette, little peach, or red suture. One

known vector of peach yellows is the plum leafhopper (*Macropsis trimaculata* (Fitch)). There are numerous leafhopper vectors of western-X, some of which are known to be present in the Southeast, including the sharp-nosed leafhopper (*Scaphytopius acutus* (Say)), the speckled leafhopper (*Paraphlepsius irroratus* (Say)), and Flor's leafhopper (*Fieberiella florii* (Stål)).

However, it should be pointed out that considerable differences in the specificity of transmission of phytoplasmas by different vector species are known, and extrapolation from one disease/vector combination to another may not be valid. Peach trees are "dead end" hosts for the phytoplasmas; their presence leads to rapid tree death, and, as the trees are dormant during the winter, they are not a host for the vectors year-round. Thus, the vectors and the phytoplasmas must overwinter in alternate hosts (possibly weed species or other native woody species). New infections occur when leafhoppers leave the alternate winter hosts, move out into the orchard, and feed on the trees. The phytoplasma associated with peach rosette has been detected in wild plums (*Prunus angustifolia*) growing adjacent to peach trees displaying rosette symptoms. Infected individuals of this species survive from year to year and may act as an alternate host and reservoir for peach rosette. However, the correlation between the occurrence of infected wild plum and the incidence of new infections in adjacent peach orchards is not absolute, suggesting that other alternate hosts exist.

GENERAL PRINCIPLES OF CONTROL

There are several control tactics for phytoplasma-associated diseases:

(1) Eradicate known diseased trees as soon as they occur. Removal of trees eliminates sources of infection within the orchard.

(2) Select propagating material from sources known to be free of disease or indexed free of disease.

(3) In cases where the insect vector is known and the time of its occurrence established, insecticide programs may be of value when directed at the vector before it becomes established in the orchard. Typically, insecticide sprays in orchards are of limited value since migrating vectors may transmit the phytoplasma before the insecticide kills them.

(4) The eradication of known alternate hosts has been effective when the alternate hosts are limited in species and number.

Antibiotics, applied by tree injection, have potential for control of phytoplasma diseases. However, antibiotic treatment is expensive and labor-intensive. The best tactic is to maintain an effective eradication program.

REFERENCES

Gundersen, D. E. and I. M. Lee. 1996. Ultrasensitive detection of phytoplasmas by nested-PCR assays using two universal primer pairs. Phytopathologia Mediterranea 35: 144-151.
Kirkpatrick, B. C. 1995a. Peach rosette. Pages 56-57 in: Compendium of Stone Fruit Diseases. J.M. Ogawa, E.I. Zehr, G.W. Bird, D.F. Ritchie, K. Uriu and J.K. Uyemoto, eds. APS Press, St. Paul, MN.
Kirkpatrick, B. C. 1995b. Peach yellows. Page 57 in: Compendium of Stone Fruit Diseases. J.M. Ogawa, E.I. Zehr, G.W. Bird, D.F. Ritchie, K. Uriu and J.K. Uyemoto, eds. APS Press, St. Paul, MN.
Kirkpatrick, B. C., G. A. Fisher, J. D. Fraser, and A. H. Purcell. 1990. Epidemiological and phylogenetic studies on western X-disease mycoplasma-like organism. Zentralblatt fur Bakteriologie 2 (suppl. 20): 287-297.
Kirkpatrick, B. C., J. K. Uyemoto, and A. H. Purcell. 1995. X-disease. Pages 57-58 in: Compendium of Stone Fruit Diseases. J.M. Ogawa, E.I. Zehr, G.W. Bird, D.F. Ritchie, K. Uriu and J.K. Uyemoto, eds. APS Press, St. Paul, MN.

Larsen, H. J. and H. E. Waterworth. 1995. Red suture. Pages 55-56 in: Compendium of Stone Fruit Diseases. J.M. Ogawa, E.I. Zehr, G.W. Bird, D.F. Ritchie, K. Uriu and J.K. Uyemoto, eds. APS Press, St. Paul, MN.
Purcell, A. H., G. Nyland, B. C. Rojir, and M. R. Heringer. 1981. Peach yellow leaf roll epidemic in northern California: effects of peach cultivar, tree age, and proximity to pear orchards. Plant Disease 65: 365-368.
Scott, S. W. and M. T. Zimmerman. 2001. Peach rosette, little peach, and red suture are diseases induced by a phytoplasma closely related to western X-disease. Acta Horticulturae 550: 351 - 354.
Seemüller, E. and J. A. Foster. 1995. European stone fruit yellows. Pages 59-60 in: Compendium of Stone Fruit Diseases. J.M. Ogawa, E.I. Zehr, G.W. Bird, D.F. Ritchie, K. Uriu and J.K. Uyemoto, eds. APS Press, St. Paul, MN.