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ELM YELLOWS OR PHLOEM NECROSIS AND ITS CONTROL

Elm yellows (formerly called phloem necrosis) is a widespread and serious systemic disease of American or white elm (*Ulmus americana*) caused by an unnamed mycoplasma-like organism (MLO). The MLO is a minute bacterium that lacks a cell wall and can assume a variety of shapes.

Figure 1. Elm showing symptoms of elm yellows.

In addition to the American elm and its cultivars, natural infections of elm yellows occurs in four other North American species of elms: winged elm (*Ulmus alata*), cedar elm (*U. Crassiflia*), red or slippery elm (*U. Rubra*), and September elm (*U. Serotina*). Red X Siberian elm (*U. Pumila*) hybrids are also susceptible. The susceptibility of rock elm (*U. Thomasii*) is uncertain. Other elm species have been experimentally infected with the elm yellows MLO. Species of Asian and European elms, and hybrids between them and native species, seem to be highly tolerant or immune.

Elm yellows occurs throughout Illinois, being more common in the southern two thirds of the state. At one time (1990) in Illinois, elm yellows killed more elms than Dutch elm disease.

Elm yellows has also been found in most other states in central and southern United States from 32° to 46° north latitude, and also in Pennsylvania, New York, New Jersey, and Massachusetts. Apparently, the northward spread of the disease is limited by cold winter temperatures. The disease is not found where the minimum winter temperatures are below -15°F (-26°C). The inability of the insect vector to overwinter could explain the northern limitation of the disease.

The MLO is limited to diseased root and stem phloem sieve tubes which are found in the innermost bark of susceptible elms. The pathogen proliferates and moves passively in the phloem sieve cells and becomes systemic throughout a tree.

For further information contact Nancy R. Pataky, Extension Specialist and Director of the Plant Clinic, Department of Crop Sciences, University of Illinois at Urbana-Champaign.

SYMPTOMS

The first noticeable foliar symptoms on American elms are usually seen between mid-July and mid-September. The symptoms include a rapid, general decline of susceptible elms which leads to the death of infected trees. The leaves commonly droop, curl upward at the margins, turn yellowish green then a bright yellow (Figure 1), finally brown, and drop off within a few weeks (Figure 2). Death of branches then follows. In highly susceptible elms the leaves rapidly wilt, wither, turn dark brown, and remain attached for several weeks. Infected elms generally die within one growing season after the onset of symptoms. Elms that exhibit leaf symptoms after early August usually survive the winter and leaf out at the normal time in the spring. These leaves wilt, turn yellow, and drop in late June or July. Elms also may sometimes die overwinter without showing foliar symptoms.

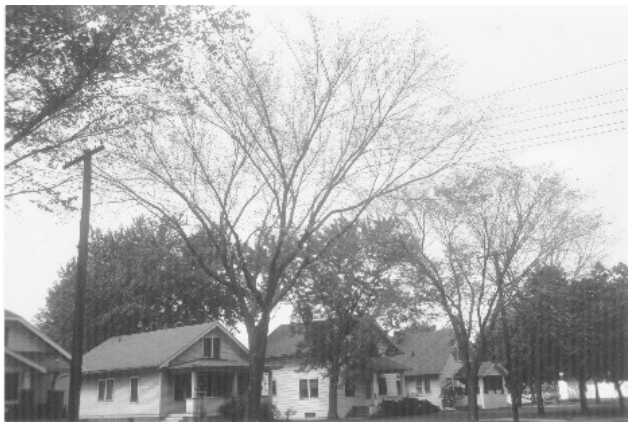

Figure 2. Foreground, tree defoliated by elm yellows: background, elm with brown leaves attached (IL Natural History Survey photo).

American elms generally show symptoms throughout the entire crown at the same time. Occasionally, one section of a tree will exhibit bright yellow leaves while the rest temporarily remains green. This latter pattern may cause the disease to be confused with Dutch elm disease. Dutch elm disease (DED) tends to mask elm yellows in doubly-infected trees.

Cedar, winged, and September elms generally die over several years, branch by branch. Red elms usually show symptoms for two years before dying. Witches' brooms (dense clusters of new growth at the tips of branches that result from the profuse sprouting of axial buds) form during the year that death occurs. Red X Siberian elm hybrids and Chinese elms also produce witches' brooms, but the trees do not die. The innermost bark and the cambial zone of infected elms change from white to yellow, then to butterscotch or tan, sometimes with flecks of dark brown, finally turning dark brown. The rest of the bark then dies. The phloem sieve cells gradually become partially filled with callose (a hard, gummy carbohydrate), distorted, then crushed, and die. Secondary phloem proliferates for a short time, then is also killed. Surface wood may also be discolored due to the diffusion of pigments from the phloem.

The inner bark has a faint odor of oil of wintergreen only in trees infected with elm yellows. In red elm the odor is somewhat like caramel or maple syrup. These odors may be detected most easily by enclosing several pieces of freshly exposed inner bark of dying trees in a small clean jar or vial for five minutes, than smelling the air inside. Detection is easiest in bark removed from the base of the trunk or the buttress roots but is also possible in bark from small branches (Figure 3). The odor disappears as the bark dies.

When trees become infected, the pathogen moves through the phloem to the fine fibrous roots. The fine roots are killed before foliar symptoms occur. As the larger roots die, foliar symptoms start to appear. General tree decline follows. The MLO's are most abundant in petioles and twigs of witches' brooms, and are more easily found in tolerant than rapidly killed trees. They occur in both living discolored phloem and in apparently normal phloem of diseased trees.

Water stress does not appear to be the cause of foliar wilting, yellowing, and death. Movement of water in the xylem of diseased elms is reduced several weeks before foliar symptoms appear. Phloem degeneration is advanced when symptoms appear in the crowns. The stomata remain partially or completely closed several weeks before phloem discoloration is apparent.

SPREAD

The most important means of spread from diseased to healthy elms is by the feeding of the whitebanded elm leafhopper (*Scaphoideus luteolus*). This insect overwinters as eggs on the corky bark of small, living elm branches. The eggs hatch over a period of about three weeks, beginning soon after the leaves unfold. Nymphs pass through five instars before becoming adults, which requires 36 to 42 days. Adult leafhoppers are present and deposit the overwintering eggs from early June until frost in the fall. Nymphs and adults prefer the inner and lower portions of elm crowns, but adults are dispersed throughout the crowns late in the season.

The leafhopper vectors become infected with the MLO by sucking juices from the phloem of leaves and succulent shoots of diseased elms. Three weeks after exposure, the insects are capable of transmitting the pathogen to healthy elms by feeding on the midribs and large veins on the underside of the leaves. Once infective, leafhoppers can transmit the MLO for the remainder of their lives. Other insects, possibly meadow spittlebug (*Philaenus spumarius*) and another leafhopper (*Allygus atomarius*), serve as vectors for the pathogen.

DISEASE CYCLE

The MLO overwinters in the open phloem sieve tubes within the roots of American elms and perhaps in the shoots of witches' brooms of red elms. The insect vectors can acquire the MLO from elm phloem approximately in mid-June when the first flush of shoot growth is complete. The leafhoppers then undergo a three-week incubation period with the pathogen, and transmit the disease from mid-July through September. Symptoms generally do not appear on an elm the year of inoculation; they appear at least three months after inoculation in very small elms; 9 to 10 months or longer in large trees. A diseased elm can be a source of inoculum roughly seven weeks after it was inoculated. The full disease cycle takes one year; secondary disease cycles are probably not important. Root grafts between closely spaced healthy and diseased elms can spread the MLO but their importance has not been established.

Outbreaks of the disease tend to be local, and spread is five to eight kilometers (3 to 4.8 miles) per year. Spot outbreaks and single tree infections are likely caused by long distance wind transport of the leafhopper vector. The MLO may be endemic in certain areas for years before causing disease. Once an outbreak occurs, most susceptible elms in a locality are killed.

The MLO exhibits a relatively high rate of infection of previously healthy elms, suggesting that it may have been introduced into the United States from another continent.

CONTROL

Saving a diseased elm tree is not possible. The control measures outlined below are aimed at reducing the spread of disease.

1. All dead and diseased elm trees should be promptly removed, then burned or buried to minimize spread of the MLO and the Dutch elm disease fungus to healthy elms. Trees dying from elm yellows and/or Dutch elm disease provide a breeding ground for elm bark beetles which transmit the DED fungus.

2. Where desired, plant Asian and European elms (e.g., *Ulmus carpinifolia*, *U. glabra*, *U. laevis, U. parvifolia,* and *U. pumila*) which appear to be highly resistant to elm yellows. However, DED can be damaging to European elms. Individual American elms were found to be resistant to the MLO but were later killed by the DED fungus.

3. Spraying healthy elms with an insecticide has been recommended for vector suppression by some researchers; others suggest that this practice is ineffective in minimizing disease. Where recommended, the first insecticide spray is timed when maturation of the spring leaf cop has taken place. The second spray should be applied when the second leaf crop appears, usually about July 15. The third spray is applied one month later (mid-August). When applying an insecticide, the registered arborist should carefully follow all precautions and directions as printed on the container label. Applications may be made using a hydraulic sprayer or a mist blower that can reach and adequately cover the uppermost foliage of the tallest elms. Twenty-five to 30 gallons of spray is required to spray a 50-foot elm with a hydraulic sprayer and 4 to 5 gallons is needed with a mist blower. Healthy elms need to be sprayed each year if they are to be continuously protected. However, we do not endorse the application of insecticides to control elm yellows, because the likelihood of beneficial effects is not good and applications must be made annually.

4. Breaking root grafts between diseased and healthy elms growing within 50 feet of each other may be beneficial although research data to support this practice is lacking. Root grafts may be broken chemically or mechanically.

    A. Apply metham-sodium or SMDC (sold as Vapam Soil Fumigant) in 3/4-inch holes drilled or punched 6 inches apart and 16 to 24 inches deep. The holes should form a single straight line midway between diseased and adjacent healthy elms. Pour 1/2 to 3/4 cup of dilute solution (1 part Vapam to 3 parts of water) into each hole. Seal the holes by tamping the soil with your heel. For best results, the soil temperature should be least 50°F (10°C). Vapam kills a small portion of the roots and thereby "isolates" the infected tree. In a row or group of elms, where an immediately adjacent tree is already infected through root grafts, a second fumigation line to break root grafts is highly desirable. Trees showing foliar symptoms should be cut down, removed, and burned or buried two days after fumigation. (Note: Do not use Vapam within 8 to 10 feet of healthy trees and within 3 feet of shrubs. The treatment will kill a small circle of turfgrass or other vegetation around each hole. The turf can be reseeded or sodded in two or three weeks. If left alone, the turf usually recovers in the next few months. Handle Vapam with care. (Be sure to follow all label precautions and directions).

B Dig a slit trench at least 2 feet deep midway between diseased and adjacent healthy elms when symptoms are first evident. (Note: The chemical and mechanical barriers described above should extend beyond the drip line of adjoining trees).

5. Experimental injection of tetracycline and oxytetracycline antibiotics into the trunks of diseased elms has resulted in symptom remission for several months to 3 years. However, tetracycline therapy is not recommended for control due to its high cost, advanced root and phloem degeneration before foliar symptoms appear, lack of lasting symptom remission after discontinuation of therapy (trees are not cured), tetracycline phytotoxicity, and the risk of MLO strains developing resistance to the antibiotics. It is doubtful that the federal EPA will ever clear the use of tetracycline antibiotics as a control measure for elm yellows.