JOURNAL OF
ARBORICULTURE

September 1979
Vol. 5, No. 9

VERTICILLIUM WILT OF LANDSCAPE TREES

by Larry D. Smith

Verticillium wilt is a significant disease that affects a large number of unrelated plants. The disease occurs in every country in the world and in every state in the United States. More than 300 kinds of plants are affected, including food and fiber crops, annual and perennial ornamentals, and landscape trees (14). When Verticillium wilt affects nursery stock, diseased plants must be rogued out. In landscape plantings valuable trees may be killed or damaged to the extent that they must be replaced.

This report is a review of Verticillium wilt in landscape trees. The causal agent, host symptoms, and control measures are discussed.

What Causes Verticillium Wilt?

There are two species of fungi that cause Verticillium wilt in landscape trees, *Verticillium dahliae* Klebahn and a closely related species, *V. albo-atrum* Reinke and Berthold. Plant pathologists disagree on the taxonomy of *V. dahliae,* but the diseases caused by the two species are similar. *Verticillium* is in a class of microorganisms known as the Fungi Imperfecti. Members of this class are fungi for which no sexual stage has been found. *Verticillium* produces verticillately branched (whorled) sporophores in culture (Fig. 1). Asexual spores (conidia) are produced at the tips of the branches and collect in a gelatinous matrix. The conidia are freed when they come in contact with water.

Verticillium is a vascular wilt pathogen that is restricted to the water conducting vessels in the host. Invasion often occurs through the root system. It is believed that the pathogen usually enters through wounds, although wounds may not be necessary for infection. After colonization of the root vascular tissue, the fungus can spread throughout the plant. The exact nature of the spread is not well understood. Two possible explanations are: 1) spores may be transported with the sap stream for some distance and create new infection sites, or 2) colonization may be extended as the fungus grows inside the vessels of the host. In trees and shrubs the root system and a portion of the trunk and branch system usually will be colonized before wilt symptoms are seen. If the plant is killed by *Verticillium,* the pathogen survives in the stems, roots, and soil surrounding the roots.

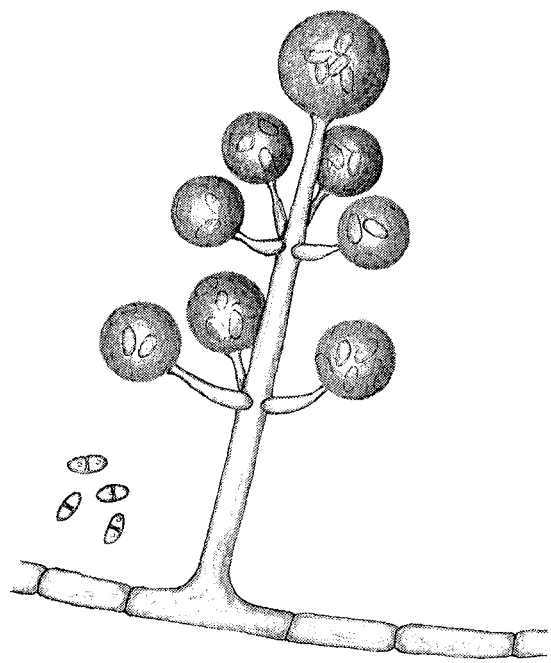

Fig. 1. Typical fruiting body of Verticillium with condiphore branching in whorls and conidia in masses at the apex of each branch.

Verticillium is a soil-borne fungus. *V. dahliae* and *V. albo-atrum* produce resting structures (microsclerotia and dauermycelia) that allow the fungi to survive in the soil for long periods of time separate from their host plants. While the spores of *V. albo-atrum* may live for only a few days in the soil, the resting structures survive six months or more (7,11). Apparently, *V. dahliae* survives most often as microsclerotia (15). Recent research has demonstrated that *Verticillium* may survive in the soil by means other than resting structures. *V. dahliae* can colonize the roots of a wide range of plants including species in which systemic infection does not occur (5,10). *V. dahliae* has colonized the roots of nonsusceptible plants as frequently as susceptible ones (6). On certain non-hosts, mycelial growth can be more prolific than on some susceptible plants (12). *Verticillium* may remain viable in a field by periodic colonization of roots of nonsusceptible plants.

How Does Verticillium Spread?

The dissemination of resting structures is a major deterrent to efforts to control Verticillium wilt. Large numbers of microsclerotia have been found in irrigation water in furrows and settling ponds in potato fields (3). These propagules have also been recovered in dust collected 20 feet above a crop of potatoes during a storm. These examples emphasize the importance of flowing water and wind in the spread of *Verticillium* in fields. Another method of propagule spread is the movement of soil. This method is particularly important when trees are transplanted from nurseries to landscape sites. *Verticillium* propagules are carried in root balls or on bare roots of infected trees and contaminate the soil where the trees are planted. In nursery fields the resting structures are spread by normal tillage operations. They may also spread in soil that adheres to equipment used in an infested field. Care should be exercised to insure that *Verticillium* is not carried into clean fields in this manner.

Which Trees Are Affected?

The host range of *V. dahliae* and *V. albo-atrum* is extensive and some of the most susceptible tree species are commonly used in landscape plantings. Among these are maple, catalpa, Russian olive, redbud, ash, tuliptree, magnolia, linden, smoketree, and American elm. The list of susceptible species is too long to include in this article. Himelick (9) listed 56 species and varieties of woody ornamental hosts of *Verticillium* in Illinois. Sinclair and Johnson (16) have published similar information for New York State. These two publications include a complete list of susceptible trees and the names of a large number of species that are tolerant or resistant to *Verticillium*. These or similar lists should be consulted when selecting a tree to replace one that has been killed by Verticillium wilt.

Fig. 2. Maple with defoliation and decline of main stem with lateral branches without symptoms.

What Are the Symptoms of Verticillium Wilt?

The symptoms of Verticillium wilt in trees are similar to those caused by other wilt diseases, but the specific symptoms are often dependent on the host. Rapid defoliation or wilting and dying of leaves on individual limbs is typical in many tree species (13). In some trees a general yellowing precedes wilting, but in others, such as ash,

defoliation may occur while the leaves are still green. Trees in the Midwest may first show leaf symptoms as early as March and as late as November (8). When wilting of leaves on individual branches goes unnoticed, the first symptom may be a sudden wilt of the entire crown of the tree.

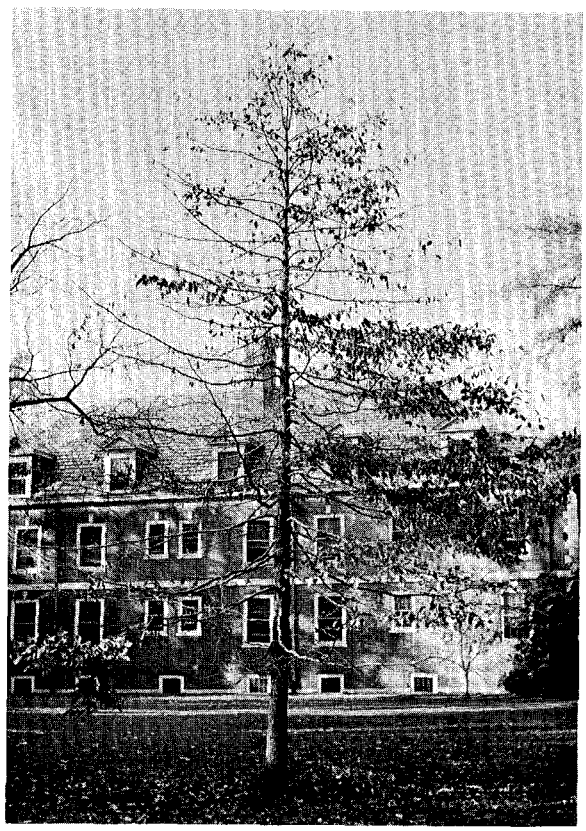

Fig. 3. Defoliation and decline general throughout the crown of this black gum.

Other external symptoms of Verticillium wilt are reduction in current twig growth, dieback of twigs and branches, and sparseness in the crown of diseased trees. Some trees such as maple and tuliptree may have elongated dead areas of bark on branches and trunks as a result of the disease (8). Trees with limited symptoms one year may show more severe symptoms the next year. Occasionally, these trees recover completely or do not have symptoms for several years. Some trees, such as elm, are tolerant to infection and commonly show stunting caused by chronically reduced growth (16). *Verticillium* normally does not kill a tree quickly, but entire plants may die within a few weeks after symptoms are first observed.

Fig. 4. Disease symptoms on shrubs similar to those found on trees. Example: Verticillium wilt of Viburnum.

Vascular streaking is another symptom of *Verticillium*-infected trees. In branches with advanced stages of wilt the sapwood will discolor in the form of bands or streaks that run with the grain of the wood. This vascular streaking may be observed by cutting across an infected branch or twig. The streaks are brown in most trees but in some species, such as maple and magnolia, they are greenish; tuliptree may have black streaks and ash may have no streaks, even when severely infected.

Many diseases produce wilt symptoms and sapwood discoloration in trees. A positive diagnosis of Verticillium wilt requires that a sample of the affected tree be examined in the laboratory and a culture made from it. Chips of wood from an in-

fected branch are asceptically transferred to sterile agar media. These are then incubated at 20-24°C for several days until the fungus grows out of the wood chips. The fungus can then be identified microscopically when the verticillately branched sporophores are observed (Fig. 1). Laboratory culturing is done at many state universities and extension facilities.

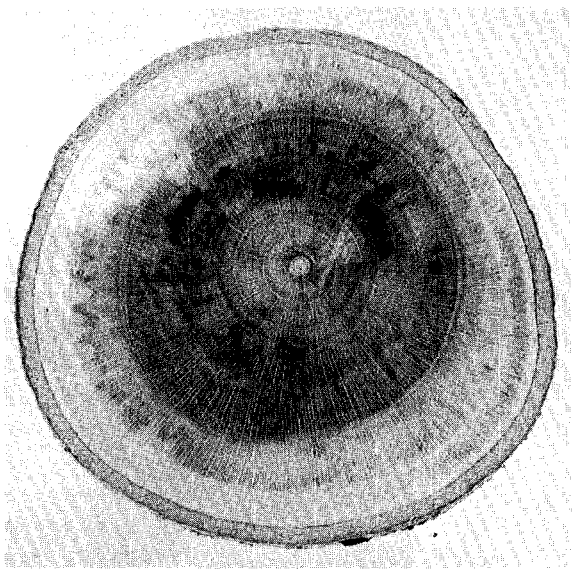

Fig. 5. Discoloration of the sapwood may be present in more rings of the xylem than that observed with other vascular fungi. Example: Verticillium wilt of maple.

How Is the Disease Controlled?

Verticillium wilt like other wilt diseases is difficult to control. One reason for this is that the commonly used fungicides are not effective against the pathogen inside an infected tree. Since *Verticillium* is a vascular pathogen, its internal location precludes the use of surface-acting fungicides in the control of the disease. A systemic fungicide (one that is absorbed and translocated within the host plant) is necessary to reach the site where the pathogen is active.

Most studies in which systemic fungicides were used to control Verticillium wilt have been conducted on crop plants. Some control of the disease has been achieved using Plantvax, Mertect (TBZ), and Benlate (benomyl). TBZ was effective against *Verticillium* in cotton in greenhouse experiments but not under field conditions (4). Benomyl has shown some promise in field plantings of cotton and strawberries (2,17).

Benlate, TBZ, and Vitavax have been evaluated for control of *V. albo-atrum* in sugar maple and Russian olive seedlings. In tests where seedlings were inoculated by infesting the soil, all the fungicides gave some degree of control when applied as a soil drench two weeks after soil infestation. Benomyl at 1500 ug/ml gave the best control, followed by TBZ. Vitavax provided little control. This study indicated that the rate of soil application of any one fungicide is important in the control of Verticillium wilt. In that same study, foliar applications of the fungicides did not control Verticillium wilt in the seedlings, but delayed expression of symptoms. An important phenomenon was demonstrated with benomyl, the chemical that has shown the greatest potential in controlling Verticillium wilt. Benomyl or its breakdown product is translocated upward in a treated plant but not downward. Foliarly applied benomyl will control *Verticillium* at the site of application, on new growth after application, and at points above the site of application but not below that site. Therefore, it does not control the fungus in the roots of a tree when it is applied on the aboveground parts. This limits the use of benoymyl to transplanted seedlings where the roots can be dipped or drenched with the fungicide. Soil applications for control of *Verticillium* in established trees has met with little success due to the problems of inadequate exposure of the entire root system to the fungicide and limited translocation of the fungicide to all infected portions of the tree. The conclusion of most studies is that chemical control of Verticillium wilt, even with systemic fungicides, is not a practical approach when treating established trees that are affected by the disease.

The best method of control of Verticillium wilt in trees and shrubs is prevention. In nurseries susceptible plants should be planted on land where *Verticillium*-susceptible crops have not been grown previously. Weeds that may act as inoculum reservoirs, such as ground cherry, lamb's quarter, pigweed, and horse nettle, should be controlled in and around nursery fields. Susceptible plants should not be planted in fields where Verticillium wilt has been a problem. Nematodes may increase the incidence and severity of the disease by interacting with *Verticillium*. General-

purpose soil fumigation will not kill all *Verticillium* propagules but will eliminate nematodes and some other plant pathogens from infested fields. Chloropicrin is partially effective against *Verticillium* (16). A fertilizaton program to maintain proper N-P-K balance in the soil can help prevent Verticillium wilt in nursery fields by promoting vigorous growth of trees and shrubs. Plants that are known to be infected by *Verticillium* should be rogued out and destroyed. Only resistant species should be planted as replacements.

In landscape plantings, a tree showing symptoms of Verticillium wilt should be watered every 10-14 days with the equivalent of 2 inches of rainfall (9). If the affected tree survives, it should receive adequate water during dry periods of summer in the following year.

Proper fertilization may help prevent Verticillium wilt in landscape plantings. Some researchers have found that wilt severity is increased by "high-nitrogen" fertilization and reduced by the use of "balanced" fertilizers (16). They recommend fertilizers having analyses such as 10-10-10 (N-P-K). Established trees showing Verticillium wilt symptoms may be fertilized to stimulate vigorous growth. A rapid response can be obtained by injecting liquid fertilizer into the soil or watering in surface-applied fertilizer. Urea applications at the rate of 13 pounds per 1,000 square feet have been recommended (8).

Dead branches and branches showing wilt symptoms should be removed or pruned back to wood showing no vascular streaking. Recently wilted branches and those showing slight wilt of leaves should not be removed immediately as these may recover in response to water and fertilizer treatments. Note that pruning of affected branches will not remove the pathogen from the tree since *Verticillium* colonizes the root system first and moves upward. After an infected tree is pruned, tools should be sterilized in alcohol to avoid spreading the *Verticillium* pathogen to healthy trees. Trees that die from Verticillium wilt should be removed along with as much of the root system as possible. Only resistant species should be selected as replacement plants.

Verticillium wilt of landscape trees and shrubs is very difficult to control. Identification of the pathogen is the first step to controlling any disease. Identification of *Verticillium* organisms can be accomplished only by laboratory culturing. Which control measures to use will depend upon the location and value of the infected tree(s). Generally, trees that are severely infected and show symptoms throughout the crown cannot be saved. Only resistant species should be planted in sites where trees and shrubs have been killed by Verticillium wilt.

Literature Cited

1. Born, G.L. 1974. Root infection of woody hosts with *Verticillium albo-atrum.* Ill. Nat. Hist. Surve Bull. 31: 209-248.
2. Buchenauer, H. and D.C. Erwin. 1971. *Control of Verticillium wilt of cotton by spraying foliage with benomyl and thiabendazole solubilized with hydrochloric acid.* Phytopathology 61: 433-434.
3. Easton, G.G., M.E. Nagle, and D.L. Baily. *1969. A method of estimating V. albo-atrum propagules in field soils and irrigation waste water.* Phytopathology 59: 1171-1173.
4. Erwin, D.C., J.J. Sims, and J. Partridge. 1968. *Evidence for the systemic fungitoxic activity of 2-(4-thiazolyl)benzimidazole in the control of Verticillium wilt of cotton.* Phytopathology 58: 860-865.
5. Evans, G. 1971. *Influence of weed hosts on the ecology of Verticillium dahliae in newly cultivated areas of the Naomi Valley, New South Wales.* Ann. Appl. Biol. 67: 169-175.
6. Evans, G. and A.C. Gleeson. 1973. *Observations on the origin and nature of V. dahliae colonizing plant roots.* Aust. J. Biol. Sci. 26: 151-161.
7. Green, R.J. 1969. *Survival and inoculum potential of conidia and microsclerotia of V. albo-atrum in soil.* Phytopathology 59: 874-876.
8. Himelick, E.B. 1968. Verticillium wilt of trees and shrubs. Ill. Nat. Hist. Sur. Bull. No. 1. 2p.
9. Himelick, E.B. 1969. Tree and shrub hosts of *Verticillium albo-atrum.* Ill. Nat. Hist. Sur. Biol. Notes No. 66. 8p.
10. Lacy, M.L. and C.E. Horner. 1966. *Behavior of Verticillium dahliae in the rhizosphere and on roots of plants susceptible, resistant, and immune to wilt.* Phytopathology 56: 427-430.
11. Nelson, P.E. and S. Wilhelm. 1958. *Thermal death range of Verticillium albo-atrum.* Phytopathology 48: 613-616.
12. Pegg, G.F. 1974. *Verticillium diseases.* Rev. Plant Path. 53(2): 157-182.
13. Pirone, P.P. 1970. Diseases and pests of ornamental plants. Ronald Press Co., N.Y. 546p.
14. Pirone, P.P. 1972. Tree maintenance. Oxford University Press, N.Y. 4th Ed. 574p.
15. Schreiber, L.R. and R.J. Green. 1963. *Effect of root exudates on germination of conidia and microsclerotia of Verticillium albo-atrum inhibited by the soil fungistatic principle.* Phytopathology 53: 260-264.
16. Sinclair, W.A. and W.T. Johnson. 1975. Verticillium wilt. Cornell Tree Pest Leaflet A-3. 7p.
17. Talboys, P.W., E.L. Frick and M.K. Davis. 1976. *Duration of effects of benomyl on growth and wilt (Verticillium dahliae) development in the strawberry, cv. Cambridge Vigour, in relation to time of inoculation.* Ann. Appl. Biol. 81(3): 305-315.

Plant and Soil Science Department
Tennessee Technological University
Cookeville, Tennessee