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Verticillium Wilt of Trees and Shrubs

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Plant Pathology

Verticillium wilt is caused by the soil-borne fungi, *Verticillium albo-atrum* and *Verticillium dahliae*. However, *V. dahliae* is the species that most commonly attacks woody ornamentals in the United States.

Verticillium is common in many soils and affects several hundred herbaceous and woody plant species, while exhibiting definite host preferences (see table 1). In Minnesota, ash, catalpa, maple and Russian olive are most frequently infected. This disease can become a serious problem on susceptible hosts in infested soils, since the fungus persists in the soil indefinitely, many times on hosts which exhibit no symptoms.

Because of its ability to spread internally or systemically within the plant and to kill the plant, Verticillium wilt is considered a serious disease. However, compared with a wilt disease such as Dutch elm disease, Verticillium is less severe. Natural stands or forested areas are rarely affected by Verticillium wilt. Verticillium wilt is often confused with other diseases or abiotic conditions. Herbicide damage, adverse environmental conditions, and mechanical damage may cause the same or similar symptoms.

Symptoms caused by Verticillium develop anytime during the growing season, but are most apt to appear in July and August. In some cases the symptoms may be more severe during or following cool weather. Symptoms appear chronically, or they may be acute and often lethal. Chronic symptoms include small, yellow foliage, leaf scorch (marginal browning), slow growth, abnormally heavy seed crops and dieback of shoots and branches. Often, the foliage on one or more branches wilts suddenly. Acute symptoms include leaf curling, drying, an abnormal red or yellow color of leaves or areas between leaf veins, partial defoliation, wilting and branch dieback. Often one branch or one side or sector of the plant is affected. Recurrence of wilt in ensuing years is unpredictable, as is its severity. In its lethal form, Verticillium wilt will cause a sudden and total collapse of the plant.

Some tree species exhibit elongate, dead areas of bark on diseased branches or trunks where the inner bark is killed. Other species, such as green ash, tend to drop green leaves before noticeable yellowing, scorching or wilting has occurred.

Streaking of the vascular tissue or wood may accompany external symptoms. This discoloration

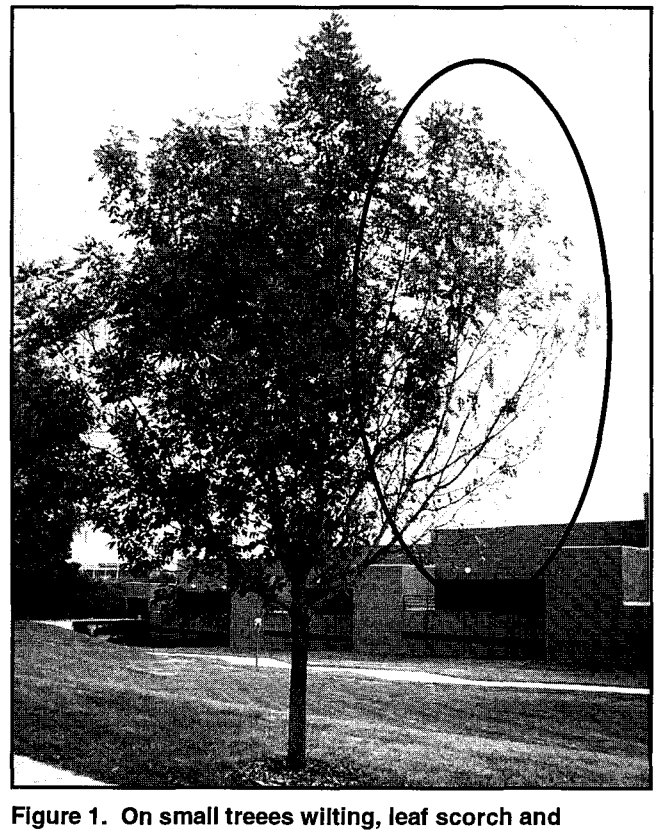

Figure 1. On small treees wilting, leaf scorch and defoliation can occur quickly on a large portion of the tree, as indicated by the circle.

Figure 2. Yellowing of the foliage may precede wilting.

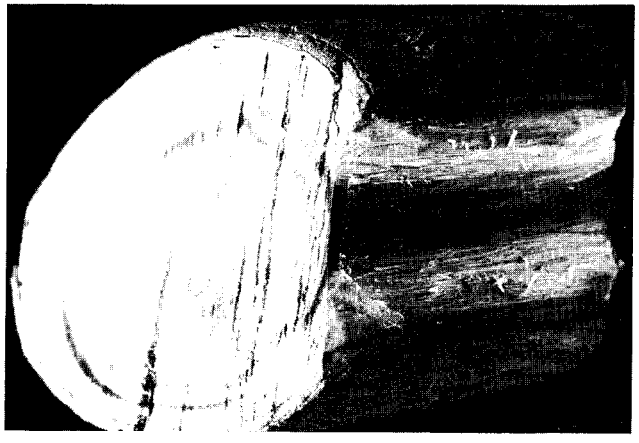

Figure 3. Discoloration in the annual growth rings is a symptom of Verticillium wilt.

may be absent during the early stages of infection and only occasionally develops in some species such as ash, *Fraxinus* species. The streaking may be scattered throughout a branch or trunk cross-section if the plant is chronically infected, or it may be confined to new sapwood, indicating a new infection. Examination of a cross-section of a larger branch or trunk will often reveal the disease history of a tree. Peeling back the bark of wilting branches may reveal streaked sapwood if the discoloration has spread up into the smaller branches. The actual color of the streaking is dependent upon the host. In maple, *Acer* species, the discoloration tends to be greenish brown, but colors range from gray-green to brown or black.

Verticillium invades the root system directly or through wounds caused naturally by root growth through the soil or soil organisms. Once in plant tissues, the fungus produces toxins and invades the xylem (water conducting tissues), moving upward in the plant via spores. Where new spores lodge in the vascular tissue a new infection begins. Toxins produced by Verticillium may kill plant cells at some distance from those directly invaded. Thus, the fungus often cannot be isolated from the apex of streaked wood or from wilting branches, even though damage is apparent there (figure 4).

In response to invasion by the pathogen, the host produces substances called tyloses or gums that attempt to close off the invaded cells to limit fungal movement in the plant. This shutting down of infected vascular tissues reduces the flow of water from the roots upward. At this point, reduced water flow and toxins often result in external symptoms.

In maple, the Verticillium fungus progresses around a growth ring by a combination of upward spread and tangential growth. If the pathogen fails to cross from one season's wood to the next, the result is remission of acute symptoms and compartmentalization (containment) of the diseased wood. The severity of chronic symptoms depends upon the extent of root and old wood damage. Acute symptoms that recur after one year or more of remission indicate a new infection moving up from the roots. Trees showing general and severe wilt cannot be saved and should be replaced with a non-susceptible species.

The fungus survives saprophytically in the soil as thread-like growths called mycelia and/or minute black resting structures called microsclerotia. In some plants the fungus may move into the leaves and persist as mycelia or microsclerotia when the leaves fall to the ground. Microsclerotia are capable of persisting for 10 or more years in the soil without a host plant. However, warm, waterlogged soils result in the rapid death of microsclerotia.

Nursery crops on land formerly used for susceptible vegetable or fruit crops are at high risk of infection. Plants from such nurseries may develop wilt after they are transplanted to landscapes. In addition, microsclerotia may form on and within the roots of plants that are resistant, but not immune, to infection and that exhibit no above-ground symptoms. This perpetuates the fungus and results in the introduction of Verticillium into uncolonized soils via infected plant material including seeds, cuttings, transplants, tubers, scions, buds and bare root trees. Infested soil on plants and equipment also spread the disease.

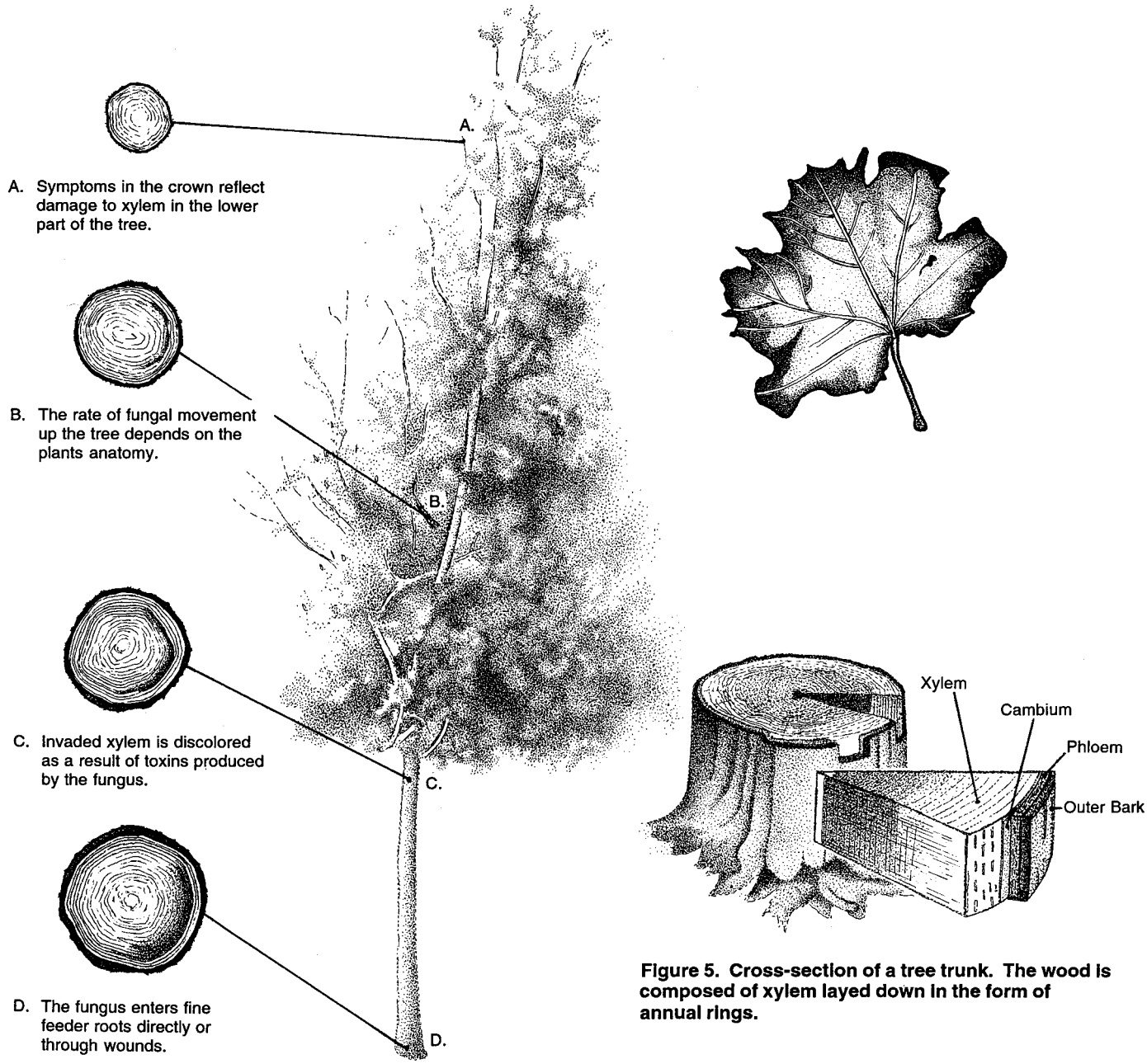

Figure 5. Cross-section of a tree trunk. The wood is composed of xylem layed down in the form of annual rings.

Figure 4. Discoloration of the xylem (sapwood) is the most apparent near the base of the tree due to root infection. Streaking in small branches (less than 2 inch diameter) is uncommon. Dieback in the crown is due to damage occuring in the roots, trunk and larger limbs.

CONTROL

Managing trees infected with Verticillium wilt will take time and knowledge. First, confirm that the symptoms are indeed caused by Verticillium wilt. The presence of typical symptoms *and* streaking of the vascular tissue is fairly diagnostic, but a laboratory culture test should be run to confirm the diagnosis.

Fungicides will not cure infected trees. Soil fumigants, if available, may be used for small amounts of garden or greenhouse soil before replanting, but are generally not feasible in landscapes.

The severity of disease development will depend on the strain of the pathogen, the level of susceptibility in the host, and environmental factors. Landscape trees with recent wilt symptoms should not be removed immediately. They may "recover" and perform fairly well with some environmental manipulation. In general, the most resistant plants

are those grown in moderately fertile soil in which the balance of major nutrients is tipped slightly toward high potassium and low nitrogen. Generously watered plants are often invaded less extensively than those under moderate to severe water stress.

When replacing trees in areas where Verticillium is present in the soil, select resistant or immune trees (Table 2). Fertilize properly to promote vigorous growth and water regularly during the growing season. Remove dead and weak branches. This does not remove the fungus from the tree, but prevents infection by other fungi. DO NOT use the chipped wood as a mulch unless it is properly heated in a compost pile.

TABLE 1. Trees and shrubs susceptible to Verticillium

Ash	Locust, black
Azalea	Maple
Barberry, Japanese	Oak, pin and red
Boxwood, Korean	(rare)
Buckeye, Ohio	Magnolia
Catalpa	Plum
Cherry, other stone fruits	Redbud
Coffee tree, Kentucky	Rose
Cork tree	Russian olive
Currant and gooseberry	Serviceberry**
Dogwood	Spirea
Elder	Smoke tree
Elm	Sumac
Honeysuckle	Wigela
Lilac	Viburnum
Linden**	

TABLE 2. Trees and shrubs resistant or immune to Verticillium

Apple	Hawthorn	Oak, white and
Arborvitae	Hickory	bur
Beech	Honeylocust	Pear
Birch	Hophornbeam	Pine
Butternut	Juniper	Poplar
Dogwood**	Larch	Serviceberry**
Fir	Linden**	Spruce
Ginkgo	Mountain ash	Sycamore
Hackberry	Mulberry	Walnut
		Willow

**Some plant species are listed in both tables (linden, dogwood). The resistance or susceptibility will depend on the cultivar and the strain of Verticillium present in the soils.

FOR ADDITIONAL information on Verticillium wilt refer to *Diseases of Trees and Shrubs* by W. A. Sinclair, H. H. Lyon, and W. J. Johnson. 1987. Cornell University Press. 574 p.

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