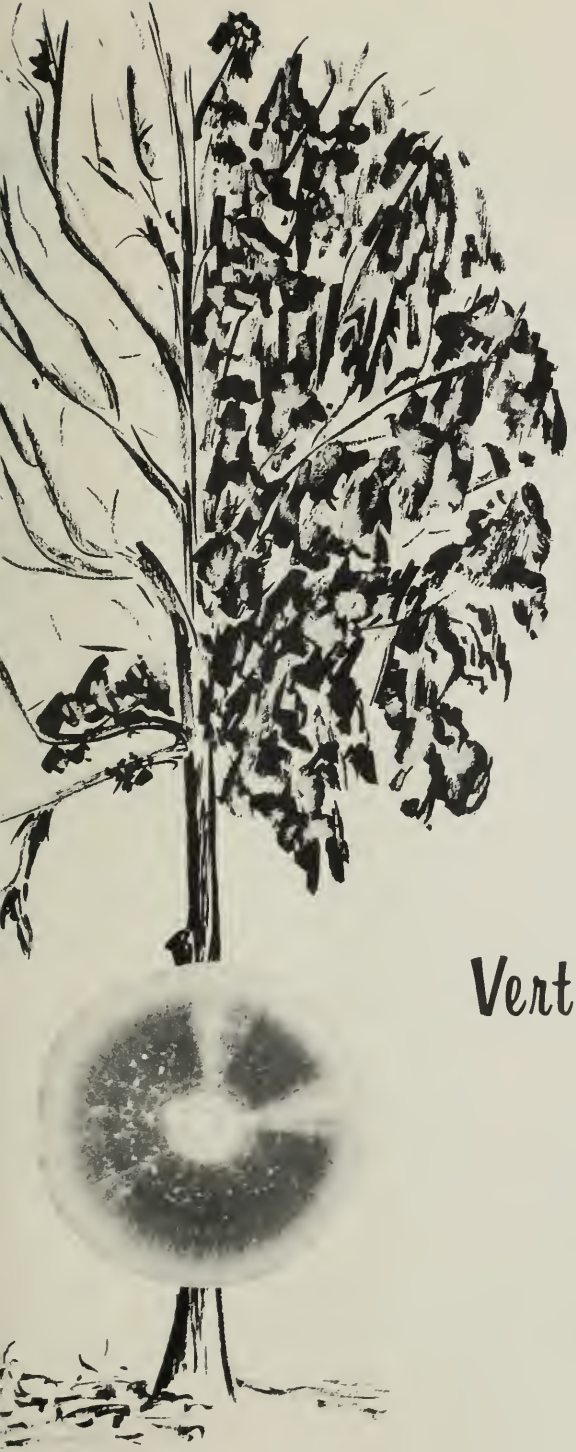

TREE AND SHRUB HOSTS OF *Verticillium albo-atrum*

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TREE AND SHRUB HOSTS OF *VERTICILLIUM ALBO-ATRUM*

E. B. Himelick

Verticillium wilt, caused by *Verticillium albo-atrum* Reinke and Berth., has become increasingly prevalent among plantings of ornamental trees and shrubs in Illinois. Persons not familiar with Verticillium wilt symptoms frequently attribute plant deaths resulting from this disease to other causes, such as transplanting shock and winter injury. Because this fungus affects a wide range of woody ornamental plants, it is difficult to estimate the economic loss it causes to nurserymen and homeowners. Rankin (1914) first reported the disease on maple in the United States and identified the fungus as a species of *Acrostalagmus*. Zimm (1918) later proved pathogenicity and identified the fungus as a species of *Verticillium*. A monograph on the disease by Rudolph (1931) lists the known host range up to 1931. Engelhard (1957) published a host index for *V. albo-atrum* that included both herbaceous and woody plants.

NEWLY IDENTIFIED HOSTS

Routine isolations have been made at the Illinois Natural History Survey from branch samples of diseased trees and shrubs since 1926. During the last 42 years *V. albo-atrum* (including *V. dahliae* Kleb.) has been obtained from several hosts growing in widely scattered areas of the state. Table 1 shows the woody hosts reported for Illinois by 1956, including 30 tree and shrub species and varieties (Carter 1938, 1940, 1945; Engelhard & Carter 1956). Since the last of these reports was published, 26 additional species and varieties of woody ornamentals, also listed in Table 1, have been identified as hosts in Illinois. Twenty-two of the plant species or varieties, identified at the Illinois Natural History Survey and listed in Table 1, are believed to be previously unrecorded hosts in the United States, as no records of these hosts were found. However, at least 3 of these 22 hosts have been reported in other countries. A few of the new Verticillium hosts reported here have been mentioned in reports which were primarily field survey reports. Where there is no indication that the fungus was isolated from infected wood and positively identified, the field report usually is not cited.

PATHOGENICITY TESTS

Since 1957 *Verticillium* isolates from various hosts have been tested at the Illinois Natural History Survey for pathogenicity to the respective host plant. Most of the trees and shrubs were available in our research arboretum. Occasionally certain species were not available and had to be purchased as seedlings. These seedlings were established in pots in our greenhouse.

Pathogenicity was tested by inoculating 5–20 plants of each species or variety, and an equal number of uninoculated plants was used as a control for each species. Each plant was inoculated by placing a drop of spore suspension in a chisel wound made in the base of the trunk. An attempt was made to reisolate the fungus within 7 days following the initial appearance of foliage symptoms. External symptoms were produced 2 weeks to 3 months after inoculation on all species except silver maple. Silver maple did not produce typical foliage symptoms, but did have scattered faint green streaks in the twigs 4–5 feet from the point of inoculation. The fungus was recovered from the discolored area 2 months after inoculation.

Pathogenicity was established for 18 of the 22 plant species listed in Table 1 as new hosts in the United States. Pathogenicity was established for an additional four plant species that were newly discovered hosts in Illinois and for an additional eight species from which *V. albo-atrum* had been isolated but for which proof of pathogenicity had not been established.

HOSTS OUTSIDE OF ILLINOIS

Table 2 lists the Verticillium tree and shrub hosts identified in addition to the 1957 list of Engelhard and those listed for Illinois in Table 1. Most of these hosts have been reported since 1957. Engelhard's list and Tables 1 and 2 include most of the world's known Verticillium wilt hosts among trees and shrubs.

VERTICILLIUM WILT SYMPTOMS

Some tree and shrub species tend first to show foliage symptoms during a limited period of the growing season; other species have symptoms appearing at any time throughout the growing season. The times when plant growth begins and ceases are variable in Illinois, since the state has three climatic zones (Rehder 1940:ii,xii). In Illinois, Verticillium wilt appears to be most prevalent in trees and shrubs in the area that demarks the line between climatic zones IV and V and appears progressively less prevalent on both sides of this imaginary line. Both temperature and moisture may be factors that contribute to the

TABLE 1.—Tree and shrub hosts of *Verticillium albo-atrum* in Illinois.

Host Plant	*Verticillium* Isolations for Illinois, 1926-1968			Pathogenicity Tests		Reported as a Host	
	First Year Isolated in Illinois	Number of Years Isolated	Number of Naturally Infected Plants	Number of Plants Inoculated	Number of Plants Infected	United States	Other Countries
Almond (*Prunus amygdalus* Batsch.)	1932	1	1			Ill. (Carter 1938)	
Ash spp. (*Fraxinus* spp.)	1957	8	10				
Black (*F. nigra* Marsh.)	1962	1	1			This report	
Blue (*F. quadrangulata* Michx.)	1957	3	3	20[a]	14	This report	
European (*F. excelsior* L.)	1964			10[b]	6	This report	
Green (*F. pennsylvanica* Marshall var. *subintegerrima* (Vahl) Fernald)	1957	3	4	20[a]	7	Colo. (Thomas 1950)	
White (*F. americana* L.)	1959	3	3	20[a]	15	This report	
Azalea (*Rhododendron molle* G. Don)	1964	1	1	10[a]	3	This report	
Barberry spp. (*Berberis* spp.)	1957	2	2				
Japanese (*B. thunbergii* DC.)	1933	5	6	10[a]	3	Mass. (Boyd 1930) Ill. (Carter 1945) N.J. (White 1936)	
Boxwood, Korean (*Buxus microphylla koreana* Nakai)	1960	1	1	5[a]	1	This report	
Catalpa spp. (*Catalpa* spp.)	1942	6	8				
Western (*C. speciosa* Warder)	1936	3	4			Ill. (Carter 1938) Kans. (Rogerson 1957)	
Coffee tree, Kentucky (*Gymnocladus dioica* (L.) K. Koch.)	1966			20[b]	6	This report	
Cork tree (*Phellodendron amurense* Rupr.)	1964			5[b]	2	This report	
Elm, American (*Ulmus americana* L.)	1931	28	406	10[a]	4	Ill. (Carter 1938), widespread (Kelsheimer & May 1940)	Canada (Quebec 1961)
var. Augustine Ascending	1955	1	1			Ill. (Engelhard & Carter 1956)	
Henry Field	1960	1	1			This report	
Littleford	1939	1	4			Ill. (Carter 1940)	
Moline	1939	3	5			Ill. (Carter 1940), Kans. (Rogerson 1957)	
Chinese (*U. parvifolia* Jacq.)	1951	1	1			Ill. (Engelhard & Carter 1956)	
English (*U. procera* Salisb.)	1955	1	1			Ill. (Engelhard & Carter 1956), widespread (Kelsheimer & May 1940)	
Slippery (*U. rubra* Muhl.)	1951	2	7			Ill. (Engelhard & Carter 1956), widespread (Kelsheimer & May 1940)	
Goldenrain tree (*Koelreuteria paniculata* Laxm.)	1948	2	3	5[a]	3	Ill. (Engelhard & Carter 1956)	
Linden, American (*Tilia americana* L.)	1939	4	4	20[a]	12	Ill. (Carter 1940)	
Little leaf (*T. cordata* Mill.)	1964			20[b]	11	This report	
Locust, Black (*Robinia pseudoacacia* L.)	1932	2	2			Ill. (Carter 1938)	Italy (Goidanich 1935)
Magnolia spp. (*Magnolia* spp.)	1951	3	3			Ill. (Engelhard & Carter 1956)	
Saucer (*M. soulangeana* Soul.)	1959	3	3	5[a]	5	Ind. (Schreiber *et al.* 1961)	
Star (*M. stellata* (Sieb. & Zucc.) Maxim.)	1963	1	1	5[a]	2	This report	
Maple spp. (*Acer* spp.)	1947	9	24			Calif. (Baker *et al.* 1940)	
Amur (*A. ginnala* Maxim.)	1958	1	1	10[a]	5	This report	
Black (*A. nigrum* Michx. f.)	1936	1	1			Ill. (Carter 1938)	

TABLE 1.—Continued

Host Plant	*Verticillium* Isolations for Illinois, 1926-1968			Pathogenicity Tests		Reported as a Host	
	First Year Isolated in Illinois	Number of Years Isolated	Number of Naturally Infected Plants	Number of Plants Inoculated	Number of Plants Infected	United States	Other Countries
Norway (*A. platanoides* L.)	1935	17	26	10[a]	3	N.C. & Va. (Hepting & Toole 1950), Ill. (Carter 1938), NW states (Bedwell & Childs 1938), Ore. (Martin 1929)	Italy (Goidanich 1934)
var. Crimson King	1960	1	1			This report	
var. schwedleri Nichols.	1937	5	6			Ill. (Carter 1938)	Holland (van der Meer 1926)
Red (*A. rubrum* L.)	1933	4	4			Ill. (Carter 1938)	Canada (Quebec 1961)
Sugar (*A. saccharum* Marsh.)	1926	22	50	20[b]	11	N.C. (Hepting & Toole 1950), Mass. (Martin 1926), Ill. (Carter 1938), N.Y. (Rankin 1914)	Canada (Quebec 1961)
Hedge (*A. campestre* L.)	1964			5[b]	4	This report	
Silver (*A. saccharinum* L.)	1964			5[c]	2	This report	
Oak, Pin (*Quercus palustris* Muenchh.)	1960	1	1	15[a]	7	This report	
Red (*Q. rubra* L.)	1960			15[b]	4	This report	
Pagoda tree (*Sophora japonica* L.)	1964			5[b]	3	This report	Italy (Goidanich 1935)
Privet, Amur (*Ligustrum amurense* Carr.)	1943	3	3			Ill. (Carter 1945)	
Persimmon (*Diospyros virginiana* L.)	1940[d]	1	1			Ill. (Carter 1945)	
Redbud (*Cercis canadensis* L.)	1941	9	18	10[a]	6	Kans. (Rogerson 1957), Ill. (Carter 1945)	
Rose, Multiflora (*Rosa multiflora* Thunb.)	1947	1	1			Ill. (Engelhard & Carter 1956)	
Rose daphne (*Daphne cneorum* L.)	1966	1	1	5[b]	2	This report	
Russian olive (*Elaeagnus angustifolia* L.)	1956	4	9	25[a]	16	Kans. (Rogerson 1957), N. Mex. (Smith 1960)	
Sassafras (*Sassafras albidum* (Nutt.) Nees.)	1940[d]	1	1			Ill. (Carter 1945)	
Smoke tree (*Cotinus coggygria* Scop.)	1936	11	12			Ohio (Ellett 1957), Ill. (Carter 1938), R.I. (Caroselli 1961)	Europe (Rudolph 1931)
Sour gum (*Nyssa sylvatica* Marsh.)	1955	2	2			Ill. (Engelhard & Carter 1956)	
Sumac, Fragrant (*Rhus aromatica* Ait.)	1943	2	2	5[b]	5	This report	
Smooth (*R. glabra* L.)	1936	6	9			Ill. (Carter 1938)	Europe (Rudolph 1931), England (Rudolph 1931)
Staghorn (*R. typhina* L.)	1960	2	2			This report	
Tulip tree (*Liriodendron tulipifera* L.)	1949	8	18	20[b]	8	Conn. (Waterman 1956), Ill. (Engelhard & Carter 1956), W. Va. (Kessler & True 1960)	
Viburnum spp. (*Viburnum* spp.)	1941	4	5				
Wayfaring tree (*V. lantana* L.)	1937	3	3			Ill. (Carter 1958), Ind. (Baines 1945)	
Doublefile (*V. tomentosum* Thunb.)	1964	1	1	5[a]	1	Ind. (Baines 1945)	
(*V. burkwoodii* Burkwood)	1964	1	1	5[b]	5	This report	
Yellowwood (*Cladrastis lutea* (Michx.) K. Koch.)	1938	3	3			Ill. (Carter 1940)	

[a] Pathogenicity was proved by inoculation of the isolated strain into the respective plant species, development of typical wilt symptoms, and reisolation of the fungus.

[b] Susceptibility was proved by inoculation with inoculum containing at least four different host isolates of *V. albo-atrum*, production of typical wilt symptoms, and reisolation of the fungus.

[c] Inoculated with a strain of *V. albo-atrum* from the sugar maple. The fungus was reisolated 2 months later from twigs having faint green streaks. No leaf symptoms were observed.

[d] *Verticillium* spp. isolated. The fungus was not characteristic of *V. albo-atrum*.

variability in the prevalence of the disease, along with the presence of a large number of tree species growing in this area. Because of the loss of elms, a greater variety of tree species is being planted than previously.

Our plant disease clinic records indicate that 34 percent of the confirmed *V. albo-atrum* isolations occurred in the month of July, 20 percent in June, 20 percent in August, 10 percent in September, 8 percent in May, 6 percent in October, and only 2 percent in March, April, and November.

For the past several years observations have been made of Verticillium wilt symptoms on various tree species (Table 3). Variation in symptom expression and in extent and speed of decline often occurs among the different species. For simplification, the table includes the more commonly observed symptoms for each of the host species listed.

SUSCEPTIBILITY OF HOSTS

A summary of our laboratory records for the past 42 years indicates that nine tree and three shrub genera are most commonly affected by Verticillium wilt. *V. albo-atrum* was recovered most frequently from branch specimens of ash, barberry, catalpa, elm, magnolia, maple, redbud, Russian olive, smoke tree, sumac, tulip tree, and viburnum.

In recent years strains of *V. albo-atrum* have been isolated that are quite virulent to numerous tree and shrub species. One strain isolated from a naturally infected pin oak tree (*Quercus palustris* Muenchh.) and inoculated into both pin oak and red oak (*Q. rubra* L.) produced wilt symptoms and internal discoloration similar to those of the oak wilt disease. The pin oak strain appears to be more virulent than maple strains in maple, ash, magnolia, and Russian olive. However, inoculation tests indicated that the pin oak strain was not pathogenic on white oak (*Q. alba* L.) or bur oak (*Q. macrocarpa* Michx.). In addition, a strain isolated from ash and inoculated into vigorous, growing trees, such as maple, redbud, and tulip tree, did not produce wilt symptoms. However, when this strain was placed in Russian olive, typical wilt symptoms were produced in 2–3 weeks.

Trees susceptible to Verticillium wilt occasionally show symptoms of this disease while they are still in a weakened condition following transplanting. Since there is evidence that *V. albo-atrum* isolates differ in

TABLE 2.—Tree and shrub hosts of *Verticillium albo-atrum* outside of Illinois.

Host Plant	Reported as a Host	
	United States	Other Countries
Apricot (*Prunus armeniaca* L.)	Widespread (Parker 1959)	Canada (Quebec 1961)
Azalea (*Rhododendron* spp.)	Mass. (Edson & Wood 1936)	
Boxwood (*Buxus* spp.)	Eastern U.S. (Hutchinson 1931)[a]	
(*B. sempervirens* L.)	Va. (Harrar 1937)	
Cherry (*Prunus avium* L.)	Widespread (Parker 1959)	Canada (Quebec 1961)
(*P. cerasus* L.)	Widespread (Parker 1959)	Canada (Quebec 1961)
Chestnut, Spanish (*Castanea sativa* Mill.)	Calif. (McCain 1963)	
Dogwood (*Cornus florida* L.)	Mass. (Holmes 1957)	
Elm, Scotch (*Ulmus campestris* L.)		Italy (Goidanich 1935), Holland (van der Meer 1926)
Holly olive (*Osmanthus ilicifolius* (Hassk.) Mouillef.)	Va. (Gruenhagen & Fordyce 1963)	
Horse chestnut (*Aesculus hippocastanum* L.)	Pa. (Armstrong 1941)	
Judas-tree (*Cercis siliquastrum* L.)		Italy (Goidanich 1935)
Magnolia (*Magnolia grandiflora* L.)	Calif. (McCain 1963)	
Maple, Japanese (*Acer palmatum* Thunb.)	N.Y. (Martin 1926)	
Oregon (*A. macrophyllum* Pursh.)	NW states (Bedwell & Childs 1938), Calif. (Mielke 1935)	
Painted (*A. mono* Maxim.)	Tenn. (Felix 1955)	
Striped (*A. pennsylvanicum* L.)	N.Y. (Hibben 1959)	
Sycamore (*A. pseudoplatanus* L.)		Canada (Quebec 1961), Italy (Goidanich 1934)
Oak spp. (*Quercus* spp.)		Russia (Krangauz 1958)
Turkey (*Q. cerris* L.)		Hungary (Georgescu *et al.* 1959)
Osage orange (*Maclura pomifera* (Raf.) Schneid.)	Conn. (Waterman 1941)	Italy (Goidanich 1934)
Peach (*Prunus persica* (L.) Batsch.)	Widespread (Parker 1959)	Canada (Quebec 1961)
Peony (*Paconia* spp.)	Kans. (Martin 1926; Rogerson 1957)	
Plum (*Prunus domestica* L.)	Widespread (Parker 1959)	Canada (Quebec 1961)
Canada (*P. nigra* Ait.)		Canada (Quebec 1961)
Rose (*Rosa* spp.)		Canada (Quebec 1961)
Tree of heaven (*Ailanthus altissima* (Mill.) Swingle)		Italy (Goidanich 1935)

[a] *Verticillium* sp. isolated.

virulence to various hosts, the transporting of infected ornamental plants from one area to another may account for the appearance of the disease in tree and shrub species not previously attacked by it. It seems likely that the continued indiscriminate movement of nursery stock from one region to another will eventually bring about a complete distribution of all virulent strains to areas where they did not exist before.

TABLE 3.—Symptoms of *Verticillium* wilt observed on trees and shrubs.

Host Plant	Type of Decline	Leaf Symptoms	Vascular Symptoms in Xylem
Ash	Twig or branch dieback. Young trees usually appear to recover.	Abscission when still green; yellowing and scorching of other leaves	Faint tan streaks (when they occur); seldom found in twigs.
Azalea	Usually rapid decline, 2-4 weeks. Shrubs usually die.	Yellowing and browning	Yellowish-brown to brownish-black streaks
Boxwood	Twig dieback. Some plants may recover.	Browning and defoliation	Brown discoloration
Catalpa	Twig or branch dieback; occasionally branches or whole tree wilts. Trees appear to recover.	Yellowing and scorching	Purplish-pink to bluish-brown upon drying
Coffee tree	Twig dieback. Young seedlings recover.	Yellowing, scorching, and defoliation	Light brown streaks
Cork tree	Branch wilt. Young trees appear to recover.	Yellowing and defoliation	Faint brown streaks
Elm	Twig dieback. Sometimes whole tree dies.	Flaccidity, yellowing, and defoliation	Brown streaks
Goldenrain tree	Usually rapid decline, 2-4 weeks. Young trees may recover.	Scorching and browning	Brown streaks
Linden	Usually branch dieback. Some trees may recover.	Yellowing and browning	Brown streaks
Locust, black	Twig dieback.	Yellowing, browning, and defoliation	Light to dark reddish-brown streaks
Magnolia	Usually rapid decline; sometimes only branches are affected.	Yellowing, browning, and defoliation	Greenish-brown streaks
Maple	Varies with species from rapid to no decline. Symptoms may disappear and reappear years later.	Scorching, browning, and defoliation	Light to dark green streaks; often difficult to find.
Oak	Twig dieback, slow decline	Flaccidity, discoloring, browning, and some defoliation; similar to oak wilt.	Brown streaks and sometimes bands; similar to condition caused by oak wilt.
Pagoda tree	Slow decline, 1-2 years.	Yellowing and browning	No discoloration observed.
Redbud	Usually rapid decline, 2-4 weeks. Trees usually die.	Flaccidity, yellowing, browning, and some defoliation	Brown streaks
Rose daphne	Slow decline over 2-3 years.	Yellowing and defoliation	Brown streaks
Russian olive	Twig dieback; may occur each year or skip a year or two and reappear. Some trees may die.	Yellowing and browning	Brown streaks
Smoke tree	Rapid decline. Trees usually die.	Margins reddish-purple; later yellowing, browning, and defoliation.	Yellowish-brown to brownish-black streaks
Sour gum	Usually rapid decline, 2-4 weeks. Trees usually die.	Scorching and browning	Chocolate brown streaks
Sumac	Rapid decline, 2-4 weeks. Shrubs usually die.	Yellowing and browning	Light green streaks
Tulip tree	Rapid decline, 2-4 weeks. Trees usually die.	Yellowing and defoliation	Greenish-brown streaks. Bark may be killed in strips on trunk.
Viburnum	Rapid decline, 2-4 weeks. Shrubs usually die.	Browning and defoliation	Light to dark reddish-brown streaks
Yellowwood	Rapid decline, 2-4 weeks. Trees usually live.	Browning and defoliation	Brown streaks

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