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ARMILLARIA ROOT ROT OF TREES AND SHRUBS

Armillaria root rot or shoestring root rot is caused by *Armillaria mellea*, a common and damaging soilborne fungus worldwide. *Armillaria* is used loosely to refer to a group of about 20 genetically distinct fungal species that can be distinguished most readily using serological techniques. Common names for this group include oak fungus, shoestring root rot, honey mushroom, and honey agaric. The latter two refer to the color of the mushroom fruiting structure of the fungus that can sometimes be seen at the base of infected trees.

Figure 1. Armillaria mellea mushrooms from base of infected tree (photo courtesy of E. Dutkey).

Armillaria root rot is widespread in the relatively heavy soils of the cooler parts of the temperate zones in the United States and Canada, particularly in the Pacific Northwest. The fungi attack about 700 species of mostly woody plants. Herbaceous plants that are susceptible include blackberry, flowering bulbs, potato, raspberry, and strawberry.

Figure 2. Armillaria mellea - bark peeled back showing rhizomorphs.

Among shade and ornamental trees, oaks and maples are the ones most commonly infected. Other woody plant hosts include azaleas, beeches, birches, black locust, boxwoods, cedars, currants, dogwoods, Douglas-fir, elms, firs, golden-rain tree, hemlocks, hickories, hophornbeam, Katsura tree, larches, lilacs, mountainashes, pines, planetrees, poplars, privets, rhododendrons, roses, sassafras, spruces, sycamores, tree of heaven, tuliptree, willows, yews, and many fruit and nut trees. The *Armillaria* fungi may infect many other kinds of woody plants if conditions are favorable for infection. Table 1 lists ornamental, fruit, and nut trees and shrubs that are adapted to Illinois and their relative resistance or susceptibility to Armillaria root rot.

Woody plants that have previously been weakened by drought, flooding, poor drainage, frost, repeated defoliation by insects or diseases, other poor soil conditions, excessive shade, polluted air or other chemical injury, or mechanical injury are most susceptible to attack. The loss of fine feeder roots from

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this disease deprives affected plants of sufficient nutrients and water, and often results in branch dieback and staghead. The fungi can be of considerable importance in the final death of weakened trees and shrubs. Serious radial and terminal growth reduction of affected plants may occur. The fungi are also responsible for butt rot in some species of trees. In fact, *Armillaria mellea* and other species have been identified as having a significant secondary role in disease complexes such as oak decline, maple blight, and ash dieback.

Armillaria is commonly found in most forest soils, so the disease may occur in forested areas or areas that were previously forested. Diseased trees may be found scattered throughout a forest stand; or infection centers composed of one or several declining trees may be scattered in the stand.

Symptoms and Signs

The aboveground symptoms cannot be differentiated easily from those produced by other root or trunk injury. The most noticeable external symptoms are premature autumn coloration and leaf drop, stunting of growth, yellowing or browning of the foliage, a general decline in the vigor of the plant, and twig, branch, and main stem dieback. Such a decline usually occurs over several years but may appear to progress very quickly as the tree shows advanced symptoms of decline and death. As decline progresses, decay of the buttress roots and the lower trunk is evident. Small plants die quickly after the first symptoms appear with large trees surviving for a number of years. Often a heavy crop of fruit (berries, cones) precedes death. In addition, a severely infected tree exudes resin, gum, or a fermenting watery liquid from the lower trunk.

Positive signs are found at the trunk base or in the main roots near the root collar. White or creamy white, paper-thick, fan-shaped sheets of *Armillaria* mycelium can be seen growing over the water-soaked sapwood when exposed. The *Armillaria* fungi have a strong mushroom odor. By the time a tree or shrub wilts and dies, the trunk is usually encircled by the fungus. With time, diseased wood becomes light yellow to white, soft and spongy, often stringy in conifers and marked on the surfaces by black zone lines. Decay in the butt and major roots of birches, firs, and other trees results in vertical cracks in the root collar. The cracks arise as trees weakened by internal decay are stressed by wind or the weight of snow or ice.

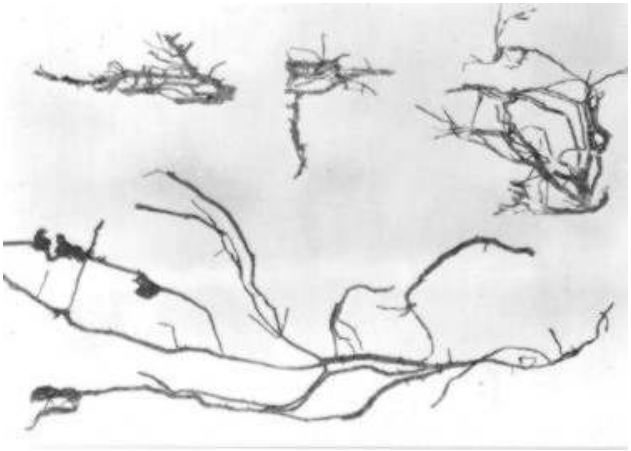

Figure 3. Rhizomorphs, or "shoestrings", means by which Armillaria fungi spread (IL Nat. History Survey photo).

The death of only a few branches can result from the killing of one or several main lateral roots. After the plant dies, rhizomorphs (slender, rootlike dark brown to black "shoestrings" with a white interior) develop beneath the bark (Figure 2 and 3). The rhizomorphs are 1 to 3 millimeters in diameter, round or flattened and branched, and they consist of hyphal strands bundled together and enclosed within suberized cells. The cordlike rhizomorphs grow over infected roots and outward from a dead tree into the soil approximately 20 inches per month. Not all strains or species of *Armillaria* form rhizomorphs in nature. Small or large clusters of yellowish brown "honey mushrooms" appear in late autumn after a rainy period (Figure 2) and persist for a week or two. The mushrooms are 2 to 10 inches tall with caps 1 to 6 inches across and are often speckled dark brown. The lower surface is light brown to white with radiating gills

which are attached to and run a little way down the stem. The mushrooms have a persistent whitish collar or ring around the upper part of the stem. The mushrooms develop near severely diseased roots and emerge through the soil, near the base of a trunk.

Disease Cycle

Armillaria mellea and most other species survive as rhizomorphs and vegetative mycelium on and in the dead and dying wood of tree stumps and roots. Sometimes the fungi can be found several feet above the soil line on the trunk of dead trees several years after being killed by *Armillaria.*

In the late autumn, mushrooms may arise from the rhizomorphs. Millions of microscopic whitish spores (basidiospores) produced in the mushroom caps are carried by the wind to dead stumps or injured bark at the base of living plants. Under favorable conditions of moisture and temperature, a few basidiospores germinate and produce a mycelium that infects the bark and later the sapwood and cambial regions. It is doubtful that the basidiospores play an important role in the occurrence of this disease. White "fans" of the mycelium develop on the sapwood, followed by the formation of rhizomorphs. The rhizomorphs advance through the soil at the rate of one or more meters (3 to 8 feet) per year in Illinois. The spread of the disease is not so much a matter of the fungus growing toward the roots of a healthy tree or shrub as it is of a healthy plant's roots growing through the soil to wood already infected with *Armillaria.* Some species of the fungus or perhaps strains within species, are virulent parasites while others are opportunistic and act selectively on small or weak individual plants. *Armillaria* also colonizes the declining root systems of plants felled or killed by other agents.

Infection occurs when *Armillaria* mycelium comes in contact with and adheres to young roots of a susceptible plant by means of a gelatinous secretion. The mycelium penetrates a root by the action of secreted enzymes that partially digest the cell walls of the young root. The fungus then grows into the root tissue between the cells. Once a plant has been invaded, the *Armillaria* fungus continues to ramify through the root and trunk tissues, even after the host plant has been dead for several years. A large stump can support the growth of rhizomorphs for decades. Trees killed by other diseases, such as Dutch elm disease, annosus root rot (*Heterobasidion annosum*), or Phytophthora root rot can be colonized by *Armillaria* and thus lead to severe local outbreaks of the disease.

A tree or shrub may die in one to several years after initial infection, depending on the vitality of the plant and environmental conditions. *Armillaria* can pass from tree to tree via root grafts. Roots of trees under stress are most easily infected. *Armillaria* is generally inhibited at soil temperatures above 79°F (26°C).

Control

1. *Armillaria* can be excluded if care is taken to insure that all planting material brought into an area is disease free. Plant only well adapted trees and shrubs in sites suited for vigorous growth.

2. Fruit trees, pine plantations, or ornamental trees and shrubs should not be planted in recently cleared areas where *Armillaria* has been a problem. These areas should be planted with nonsusceptible crops such as corn, small grains, and grasses for a few years to help eliminate the fungus. Another possibility: use the infested area for lawn, vegetable garden, rockery, or for annual and biennial flowers.

3. Clean cultivation of an orchard can help distribute *Armillaria* infected wood to other areas not infested with the fungus. A groundcover crop should be used to replace the procedure of clean cultivation.

4. In orchards and other areas where *Armillaria* is established, diseased trees and shrubs should be carefully dug up, including the stump, all large roots, stakes, or other wood harboring the fungus, and burned on the site instead of transported to a dump. All pruning wastes should be burned rather than incorporated into the soil to prevent the formation of new disease centers. Deprived of their food supply, any rhizomorphs left in the soil will soon die. Eradicating *Armillaria* from a site requires a thorough removal of all diseased and dead wood.

5. Plants found to be infected in only a few roots or a small part of the root collar can be saved for a time by carefully removing the soil to expose the root collar and buttress roots to aeration and drying from mid-spring to late autumn. Infected bark and wood on large roots, buttress or trunk should be excised back to healthy tissue. Replace the soil with *Armillaria* free soil before the first heavy frost.

6. Maintain tree and shrub vigor by good cultural management practices: (1) regular fertilization, based on a soil test; (2) thorough watering during extended droughts; and (3) insect and disease control. Where possible, provide for adequate soil drainage in heavy, poorly drained sites. Avoid all root damage to established woody plants in areas where construction is to occur. This is particularly relevant to oak groves. Avoid soil fill and soil removal around valuable trees and shrubs.

7. If the precise source of infection is known and cannot be removed, it should be possible in some cases to prevent the rhizomorphs from reaching the trees and shrubs to be protected by sinking a sheet of heavy polyethylene vertically into the soil between diseased and healthy plant(s), provided it extends far enough laterally (several feet beyond the outer dripline) and at least a meter (3 feet) into the soil. A suitable deep ditch would have the same effect.

8. Fungicides applied to infected trees are not recommended.

Table 1. Resistance or Susceptibility to Armillaria Root Rot of Certain Woody Plants Adapted to Illinois[a]

COMMON NAME

Immune or Highly Resistant

Abutilon or flowering maple
American sweet gum
American holly
American plum
American chestnut
American or sweet elder
Amur cork tree
Austrian pine
Bald cypress
Bayberry
Big-leaf maple, Oregon maple
Black cherry
Boxelder
Boxwood
Callery pear
Cherry plum
Chinese wisteria
Chinese elm
Clematis
Colorado or white fir
Common persimmon
Common catalpa
Dawn redwood
English holly
French pear
Ginnala maple, Amur maple
Hackberry
Holly mahonia, Oregon grape
Japanese pagoda tree
Japanese maple
Japanese flowering crabapple
Kentucky coffee tree
Maidenhair tree
Mock-orange
Modesto ash
Mulberry
Osage orange
Pawpaw
Pecan
Planetrees or sycamore
Prairie crabapple
Rose of Sharon
Russian olive, oleaster
Scots pine, Scotch pine
Shademaster honeylocust
Shining sumac
Smoke tree
Southern magnolia
St. Johnswort (shrub form)
Staghorn sumac
Swamp birch
Tamarisk
Thornless honeylocust
Tree of heaven
Tulip tree

Moderately Resistant

Black locust
Bridal wreath
Common pear
Douglas fir
European larch
Glossy abelia, white abelia
Golden raintree
Green Japanese barberry
Honeysuckle
Hybrid larch
Japanese larch
Japanese zelkova
Lalande pyracantha
Mazzard sweet cherry
Norway spruce
Scarlet firethorn
Silk tree, mimosa
Washington thorn
Yellowwood
Yew

Table 1. Resistance or Susceptibility to Armillaria Root Rot of Certain Woody Plants Adapted to Illinois[a] (cont.)

Susceptible

American beech	Mahaleb cherry
Apple	Narrowleaf firethorn
Bush cherry	Oakleaf hydrangea
Chinese chestnut	Peach, flowering peach
Chokecherry	Privets (except Japanese privet)
Colorado blue spruce	Prostrate junipers
Cutleaf crabapple	Redbud
Eley crabapple	Rock cotoneaster
English walnut	Roses
European white birch	Rowal paulownia, Empress tree
European beech	Sargent crabapple
European hornbeam	Serian spruce
Flowering almond	Shrubby St. Johnsworth
Golden chain tree	Siberian crabapple
Gooseberry	Sweet chestnut
Grapes	Tea crabapple
Japanese flowering cherry	Weigela
Katsura tree	Western red cedar
Lilac	Willows

[a] A partial listing taken largely from Resistance or Susceptibility of Certain Plants to Armillaria Root Rot, by Dr. Robert D. Raabe, Division of Agricultural Sciences, University of California, Leaflet 2591.