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Armillaria Root Disease

R.E. Williams,[1] C.G. Shaw, III,[2] P.M. Wargo,[3] and W.H. Sites[4]

[1]Plant Pathologist, U.S. Department of Agriculture, Forest Service, Intermountain Region, State and Private Forestry, Boise, ID.
[2]Research plant pathologist, U.S. Department of Agriculture, Forest Service, Pacific Northwest Forest and Range Experiment Station, Juneau, AK.
[3]Research plant pathologist, U.S. Department of Agriculture, Forest Service, Northeastern Forest and Range Experiment Station, Hamden, CT.
[4]Plant pathologist, U.S. Department of Agriculture, Forest Service, Southern Region, State and Private Forestry, Asheville, NC.

Armillaria root disease is found throughout temperate and tropical regions of the world. In the continental United States, the disease has been reported in nearly every State. Hosts include hundreds of species of trees, shrubs, vines, and forbs growing in forests, along roadsides, and in cultivated areas.

The disease is caused by fungi, which live as parasites on living host tissue or as saprophytes on dead woody material. The fungus most often identified as causing the disease is *Armillaria mellea* (Vahl: Fr.) Kummer. Recent research, however, indicates that several different but closely related species are involved. Therefore, the generic term *Armillaria* is used to refer to this group.

These fungi are natural components of forests, where they live on the coarse roots and lower stems of conifers and broad-leaved trees.

As parasites, the fungi cause mortality, wood decay, and growth reduction. They infect and kill trees that have been already weakened by competition, other pests, or climatic factors. This type of activity occurs throughout the United States--especially in deciduous forests of

the East. The fungi also infect healthy trees, either killing them outright or predisposing them to attacks by other fungi or insects. Such behavior typically occurs in the relatively dry, inland coniferous forests of the Western United States.

Common Names

Armillaria and the disease it causes have several common names. Shoestring root rot refers to the rootlike fungal structures, called rhizomorphs, that spread the fungi. The names honey mushroom, honey agaric, mushroom root rot, or toadstool disease refer to the mushrooms produced. Conifers often respond to infection by producing a copious flow of resin, hence, the names resin glut or resin flow. When oaks are the common host, *Armillaria* is often called the oak fungus.

Detection and Diagnosis

Characteristics of Infected Trees. Because these fungi commonly inhabit roots, their detection is difficult unless characteristic mushrooms are produced around the base of the tree or symptoms become obvious in the crown or on the lower stem.

Crown symptoms on conifers and broad-leaved trees vary somewhat. Generally, however, the foliage thins and discolors, turning yellow, then brown; branches die back; and shoot and foliar growth are reduced.

On large, lightly infected or vigorous trees, crown symptoms develop over a number of years (fig. 1), until the trees die. Conifers, particularly Douglas-fir and western larch, frequently produce a larger-than-normal crop of cones, known as stress cones, shortly before they die.

Figure 1. - *The Douglas-fir on the right with sparse foliage and poor shoot growth has been infected for a number of years.*

Figure 2. - *This subalpine fir was killed rapidly and retained its full complement of needles.*

On small, extensively infected or low-vigor trees, crown symptoms develop rapidly: the foliage quickly discolors, and the tree often dies within a year (fig. 2). On such trees, premature foliage loss and reduced shoot and foliar growth may not be apparent.

Trees affected by prolonged drought or attacked by rodents, bark beetles, or other fungi, particularly other root pathogens, can produce crown symptoms similar to those caused by *Armillaria.* Thus, additional evidence, often found on the roots and on the lower stem, is needed to diagnose the disease (figs. 3 and 4).

On most conifers, the infected portions of the lower stems are somewhat enlarged and exude large amounts of resin (fig. 5). Infected portions of the roots frequently become heavily encrusted with resin, soil, and sometimes fungal tissue.

Figure 3. - *Crown symptoms alone, such as those on this ponderosa pine, are not sufficient to identify the presence of*Armillaria

Figure 4. - *Removing the bark at the base of the symptomatic ponderosa pine in figure 3 reveals the characteristic mycelial fans.*

Figure 5. - *Resin on a Douglas-fir. The first resin produced in response to the fungi turns dark brown but later is often covered with resin that retains a white sheen.*

In contrast, infected portions of broad-leaved trees sometimes develop sunken cankers covered with loose bark or bark infiltrated with gum and other exudates. But most often

these cankers are inconspicuous or absent.

If *Armillaria* is present, removing the bark covering infections will expose the characteristic, white mycelial mats or the rhizomorphs that grow between the wood and the bark.

The white mycelial mats are marked by irregular, fanlike striations; hence, they are often referred to as mycelial "fans." The thick mats decompose, leaving impressions on the resin-impregnated inner bark. (See cover photo.)

Rhizomorphs growing beneath the bark are flat, black to reddish brown, and up to 0.20 inch (5 mm) wide (fig. 6). They have a compact outer layer of dark mycelium and an inner core of white mycelium. Rhizomorphs also grow through the soil. Except for being cylindrical and about half as wide, subterranean rhizomorphs are similar to those produced beneath the bark.

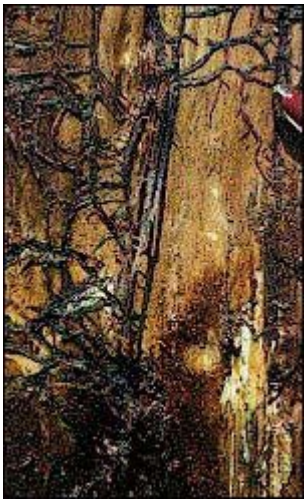

Figure 6. - *Shoestringlike rhizomorphs be-tween the bark and the wood of a grand fir.*

Mushrooms, the reproductive stage of these fungi, confirm the presence of Armillaria. The short-lived mushrooms may be found growing in clusters around the bases of infected trees or stumps (figs. 7 and 8). They are produced sporadically in late summer or autumn, and are most abundant during moist periods.

Figure 7 - *A cluster of mushrooms at the base of a western white pine. The spores seem to be of limited importance in spreading the fungi.*

Figure 8 - *A cluster of mushrooms on the root of a red oak.*

The mushrooms of the different species vary somewhat but generally have yellow or brown stalks about 2 inches (5 cm) long, and a ring is sometimes found around the stalk just below the gills. The stalks have honey-yellow caps, 2 to 5 inches (5 to 12.5 cm) across. The upper side of the cap may be slightly sticky and dotted with dark brown scales; underneath, the cap has light-colored gills, which produce millions of light yellow to white spores.

Armillaria causes a white rot of infected wood. When wood first begins to decay, it looks faintly water soaked; then it turns light brown. In the advanced stages of decay, wood becomes light yellow or white (fig. 9) and may be marked by numerous black lines. Advanced decay is spongy in hardwoods but often stringy in conifers.

Figure 9 - *Wood of Douglas-fir in advanced stages of decay is light yellow and stringy.*

In live trees, stem decay, referred to as butt rot, is confined largely to the inner woody tissues. Butt rot seldom extends more than a few feet above the ground.

Patterns of Infection. Trees of different species and sizes may be killed individually throughout stands. This pattern often occurs in managed stands reforested with species unsuited to the site but may also occur in unmanaged stands.

Armillaria also kills trees-primarily conifers-in a pattern of progressively expanding disease centers (fig. 10). These centers develop in managed or unmanaged stands and vary from small areas affecting several trees to areas of up to 1 ,000 acres (400 ha). Within disease centers and on their expanding margins, trees in varying stages of decline are normally

present. One or all species and sizes of conifers may be affected.

Figure 10 - *Three disease centers in a virgin, mixed conifer forest in western Montana. The lowermost center covers nearly 20 acres (8 ha).*

Infection and Spread

Armillaria may live for decades in coarse woody material. From this food source, the fungi spread to liv-ing hosts. Spread occurs when rhizomorphs, growing through the soil, contact uninfected roots or when uninfected roots contact infected ones.

Rhizomorphs can grow for distances of up to 10 feet (3 m) through the upper soil layers, and they penetrate the roots by a combination of mechanical pressure and enzyme action. The rhizomorphs' growth and ability to penetrate roots depend upon the specific fungus, the type and amount of the food source, the soil environment, and the host species.

When uninfected roots contact infected ones, the fungal mycelium invades uninfected roots without forming rhizomorphs. Such spread is common in dense stands where root contact is frequent.

Vigorously growing trees often confine the fungi to localized lesions and limit their spread up the roots by secreting resin and rapidly forming callus tissues. But when infected trees are in a weakened condition, *Armillaria* spreads rapidly through the roots. If the growth of the tree improves, fungal growth is checked. Such interaction occurs throughout the life of an infected host until (1) it outgrows the fungi or (2) the fungi reach the root collar, girdle the stem, and kill the tree.

When infected live trees are cut, *Armillaria* rapidly spreads into the uncolonized parts of roots and stump. As a result, the food source increases and may be responsible for initiating new disease centers.

Damage

Outright mortality is the most frequently observed result of infection; it can be a problem in timber stands, recreation areas, or orchards. On the other hand, mortality can improve resource values - particularly in dense, young coniferous forests of the Western United States.

Infection also results in growth reduction and wood decay. Growth reduction often goes undetected or is ascribed to other agents and thus is probably underestimated. Likewise, decay extends only a few feet into the lower stem and will often go unnoticed until the tree fails or is cut. Tree failures are significant hazards in recreation and urban areas.

Management

Because these fungi are indigenous to many areas and live on a wide variety of plants and woody material, their eradication or complete exclusion is not feasible; management should be directed toward limiting disease buildup or reducing its impact.

Where individual trees are of high value, chemical fumigants, including chloropicrin, methyl bromide, and carbon disulfide, can reduce the infection level. These fumigants are applied in and around the base of infected stems or in holes left after trees have been uprooted.

Cultural management shows promise for dealing with *Armillaria* in commercial forests. Management considerations include (1) reforesting stands with a mixture of species ecologically suited to the site and not obviously infected by *Armillaria*; (2) maintaining vigorous tree growth without causing undue damage to soils; (3) minimizing stress to and wounding of crop trees; and (4) reducing the food source by uprooting infected or susceptible root systems and stumps.

Where infection is limited, integrating the first three considerations into management

prescriptions may be adequate.

Where infection levels are high, such as in root disease centers, all four considerations may be used. Stumps and roots should be removed in a zone extending at least 33 feet (10 m) beyond the visible margin of the disease center because root systems in this area are likely infected.

Sometimes other pests or stand conditions may be more significant than *Armillaria*. A thorough evaluation of existing or potential pest activity, site and stand characteristics, and the feasibility of various options should always be made before selecting a management alternative.

Assistance

Assistance in recognizing and dealing with *Armillaria* is available from Extension offices; municipal or State forestry offices; or Forest Pest Management and Research staffs, U.S Department of Agriculture, Forest Service.

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