Root Rots in the East

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Root rot diseases kill many deciduous fruit trees in orchards in the eastern part of the United States each year. That annual loss of trees in bearing orchards is not particularly spectacular, but the loss of trees is quite important and often is of great concern to orchardists. Since the death of fruit trees from root rot most frequently occurs after they reach bearing age, the loss to the grower includes the investment in growing the tree as well as the potential production of the tree. Besides, the reduced yield of small or low-quality fruit on infected trees markedly increases the cost of production.

Several species of parasitic fungi cause infectious root rot diseases of fruit trees. Some of the diseases, such as the black root rot of apple, caused by *Xylaria mali*, are restricted in distribution to certain areas and a few crops. Others, such as armillaria or mushroom root rot, caused by *Armillaria mellea*, affect many kinds of woody plants in most of the United States as well as many other countries.

The root rot diseases, caused by the several fungus parasites, have similar symptoms on the above-ground parts of the tree. Fruit trees affected with root rot show stunting of leaves and branches and yellowing and wilting of leaves. Death of an affected tree occurs after the bark and cambium of the trunk are killed by a root rot fungus.

On the above-ground symptoms one cannot make a sure diagnosis of root rot because somewhat similar symptoms result from root injury or trunk girdling by insects, rodents, cold, or chemicals. Diagnosis of parasitic root diseases can be made only by examination of the affected roots or of specialized fruiting structures such as sporophores, rhizomorphs, or sclerotia. Without microscopic examination and isolation of the causal fungus, it is often impossible to diagnose the cause of the root rot.

The following root rot diseases of deciduous fruit trees in the Eastern States are discussed here: White root rot of apple, black root rot of apple, and clitocybe root rot.

**The White Root Rot of Apple** is due to a fungus, *Corticium galactinum*, which has been known as a parasite of apple trees for many years. In 1902 an investigator of the Department of Agriculture reported that the fungus was a widely distributed parasite of apple roots in West Virginia, Kentucky, southern Illinois, Arkansas, and Oklahoma. The disease was said to have caused considerable loss to apple growers in those States during the preceding 30 years in orchards set out on newly cleared land. It was suggested that the pathogen was transferred to young apple trees from nearby oak trees. Studies started in 1932 disclosed that white root rot was causing death of many trees in orchards in Virginia, Maryland, Tennessee, Delaware, and Indiana. In North Carolina white root rot has been found on bearing and young apple trees in scattered orchards.

The disease is confined to orchards that were set on newly cleared land or orchards near woods. The pathogen has been found growing abundantly on the roots of blackberry, dewberry, Japanese wineberry, dogwood, sumac, white campion, holly, and kalmia. In 1951 *C. galactinum* caused a root rot of ornamental shrubs and herbaceous perennials of many kinds in one place.
in Maryland. Included in the list of susceptible plants were species of blue wild indigo, winter jasmine, iris, pearl bush, peony, flowering almond, double flowering plum, spirea, viburnum, and peach.

*C. galactinum* has been reported as causing a root rot of white pine and a decay of firs, western white cedar, and spruce. According to E. A. Burt, of the Missouri Botanical Gardens, the white root rot fungus sporulates on a variety of substrata, including wood of both coniferous and broad-leaved species. L. T. White in Canada gave a revised description of the fungus in 1951 and listed it as occurring from Canada to Texas and westward to the Pacific coast, Europe, West Indies, and Japan.

The fungus appears on the surface of affected apple roots as a white or cream-colored layer of mycelia, which may persist for several years on old apple stumps and roots. The wood under the bark of affected roots often shows characteristic bird's-eye or zonate spots. At times affected roots appear knotted or gnarled. The wood of diseased roots, after being completely rotted, is very soft and light in weight. The pathogen produces spores on an inconspicuous hymenial layer on the surface of roots, on the surface of soil at the base of trees, or in open pockets in the soil. This layer, when it is dry, is white to cream-colored. It is waxy cream to ochraceous buff when it is moist.

During 15 years or more of observations of the disease in apple orchards, J. S. Cooley, of the Department of Agriculture, found that apple trees were frequently attacked at the collar by the white root rot fungus—the fungus apparently did not spread readily through the soil but by spores carried by wind or manual means. Trees died within 2 years after the above-ground parts first showed symptoms of the disease, but trees of all ages may be killed by white root rot.

Dr. Cooley found that trees 37 years old at the start of an experiment in two orchards in Virginia continued to die over an 8-year period, when more than one-half of apple replants in infested soil became infected with the rot. In an orchard in North Carolina young trees planted in sites where trees affected with the rot had been removed were killed within a year.

Cooley and Ross W. Davidson in 1940 reported successful inoculation of the roots of young apple trees with pure cultures of the fungus.

The black root rot disease of apple, caused by *Xylaria mali*, occurs in the southeastern and south central parts of the United States—primarily from Maryland to South Carolina west to Arkansas and Illinois. There black root rot is probably the most common and destructive parasitic root rot of apple trees. The fungus attacks oak and probably other deciduous woods. Maple, hackberry, grape, sassafras, and ash have been infected by inoculation, but we do not know whether they are susceptible to infection under natural conditions.

Large, fingerlike fruiting bodies frequently are found at the base of diseased trees. These spore-bearing stromata are at first white and produce many one-celled hyaline spores. Soon they turn black, and by autumn mature ascospores have formed in their surface layer. Another characteristic is that the surface of affected roots is covered with a black, charcoallike stromatic coating. The wood of affected roots becomes brittle; trees in advanced stages of the disease are easily uprooted, for the roots break off easily near the trunk under the strain of uprooting.

The symptoms of black root rot above ground are like those of other serious root disorders. The leaves on diseased trees have a pale-yellow cast. Many lateral buds fail to grow. The terminal growths are short and give the appearance of a thin foliar growth. In later stages one or more of the main branches may die. Others may remain
normal, but more commonly death of the whole tree results. Bearing trees in late stages of the disease tend to bear heavily, but the fruits are small and of a poor quality.

The black root rot disease does not kill apple trees so quickly as does the white root rot disease. Although trees of all ages are susceptible, most trees that die from black root rot are at least 10 years old. Affected trees are rarely killed in a single season after the time of infection. The fungus spreads from root to root of an individual tree and within 3 or 4 years after infection a tree may die. Each year a few more trees in an orchard carrying the fungus are affected, so that eventually 25 percent or more of the trees may be killed or removed because of the disease. Where a tree has died or has been removed because of black root rot, the site is undesirable for replanting. Since the length of time the organism may persist in the soil is known to be 16 years or more, replanting would be risking a recurrence of the disease.

The best temperature for the growth of the black root rot fungus and also for infection is near 77°F. No growth occurs above 95° or below 41°. The fungus can penetrate directly through the bark or enter through wounds. Peak infection seems to come in July, because of a lessening of metabolic activity of the roots in midsummer.

The most important source of inoculum is the mycelium in the roots of diseased trees, even though ascospores are produced in great abundance and undoubtedly are carried long distances by wind and other factors. The fungus may survive the death of the host plant by many years and serve as inoculum for infection of replanted apple trees.

A high incidence of black root rot has been found within 2 to 3 years on young apple trees planted in thoroughly infested orchard soils in West Virginia. They tested a large number of clones of Malus species exposed to natural infection and found that none of the clonal stocks or seedling stocks inoculated with Xylaria mali in pure culture exhibited any promising measure of resistance to the fungus.

Another species of Xylaria, X. polymorpha, has been reported to occur on apple in Virginia, New York, and Georgia. That fungus is not so vigorously parasitic as is X. mali.

In North Carolina I have found armillaria root rot to be the greatest cause of death of peach trees. The disease has also killed apple and peach trees in clay and sandy soils in several other sections of North Carolina. The greatest prevalence of the disease is in orchards planted on newly cleared land. In such locations pieces of wood invaded by the fungus serve as inoculum for infecting roots of fruit crops.

In the Southeastern States another mushroom fungus, Clitocybe tabescens, causes a root rot of pear, peach, apple, and other woody plants. The clitocybe root rot disease is so similar to armillaria root rot in symptoms and its effect upon the plant that positive diagnosis cannot be made without the presence of the mushrooms or cultural studies. One major difference between a mushroom of Clitocybe and Armillaria is that the latter has an annulus or ring on the stipe and the former does not.

Control of root rot diseases of tree fruits in eastern United States depends primarily on the avoidance of the diseases by planting trees in soil that is not harboring the pieces of woody material in which a root rot fungus is present.

Care in removal of diseased trees to avoid spreading inoculum of the root rot fungus from one place to another is necessary. Resistant root-stocks are not known or are not satisfactory for one reason or another. The use of chemical fumigants to kill the fungus in woody material in the soil before planting trees has possibilities.

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