caused by the Septorias on Kentucky bluegrass. Usually the leaf tip dies or gray to brown spots develop along the leaf blade. The spots may be bordered by red to yellow bands. The spots fade to a straw color, and the dark-brown or black fruiting bodies can be seen scattered along the faded part of the spots. The disease develops during cool wet weather and may cause extensive defoliation.

The spores within the small fruiting bodies can persist for a long time, and old infected leaves can be blown around or scattered and become the source of new infections.

Control of septoria infection in annual grasses is aided by rotation with nonsusceptible crops and sanitation. Perennial grasses resistant to leaf blotch must be developed to effect control. Differences exist among strains of grasses and newer varieties should help reduce effects of the disease.

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For further reading on leaf diseases of forage grasses:

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C. S. Reddy and James Godkin: A Bacterial Disease of Brome Grass, *Phytopathology, volume 13, pages 75–86, 1923.*

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See also page 262.

Root and Crown Rots of the Grasses

Roderick Sprague

Range and pasture grasses during various stages of their life are subject to attack by soil-borne parasitic fungi.

Some parasitic fungi can stand considerable drought, but most of the relatively delicate organisms need plenty of moisture. During the early life of the grass host, the fungi are well favored because the grass seeds germinate in moist soil, where the fungi are waiting. Later in its life grass may form mats of foliage, which help to keep the humidity high and therefore favor root and crown rots.

Root rots and crown rots are in total probably the most destructive group of parasites of the grass family. In parts of the Great Plains, for instance, they were one of the chief reasons why regrassing after the drought years was so difficult. Losses up to 100 percent from seedling blight, for instance, were general.

Most of the soil-borne fungus parasites of grasses develop fine filamentous mycelium without producing any conspicuous fruiting bodies. A few develop small, hard, black sclerotia, which later give rise to small fruiting bodies about one-third inch high. A number of them produce colored or obscure masses of spores on diseased parts. Others form microscopic or nearly microscopic fruiting bodies in diseased parts.

The identification of the various root rots and crown rots must depend to some extent on microscopic exami-

nation of the diseased tissue and frequently only after isolation of pure cultures. Certain symptoms, however, aid in distinguishing some of the diseases without great difficulty.

SOME OF THE FUNGI in the soil can survive alone and are called soil inhabiting. Most of them, however, depend on humus in the soil to survive during part of their life. Such fungi can grow through the soil for some distances away from the nearest particle of humus, but they must retain a life line of mycelium with the piece of humus from which they started. Such fungi are called soil invading.

Most of the root rot fungi are soil invading and can therefore be starved out by prolonged fallowing. They need nitrogen, phosphorus, and other chemicals to grow, the same as plants do. They tend to accumulate in the area next to the roots in the soil—the rhizosphere. The region teems with activity from fungi, bacteria, and the plant roots. As the available supply of soil nutrients may become depleted, the fungi sometimes invade living cells in the roots of the grasses in search of food.

If they maintain a mild form of parasitism with mutual exchange of nutrients, both host and fungus may benefit. Actually these mycorhizal fungi serve as root hairs. They grow out into the soil, seeking nutrients which they carry through their mycelial filaments into the cells of the plant. The mycorhizal fungi take from the plant but give food from the soil in exchange. If the parasitism is favorable to both fungus and plant it is called symbiosis.

Usually in grasses, however, when fungi invade the roots they are destructively parasitic. In young plants death may quickly follow. In older ones the process may be prolonged as a slow necrosis and "going-out" of old stands. All soil fungi are not parasitic. Some cannot attack living plant tissue. They are called saprophytes. Some are weakly parasitic or are starved into invading living tissue. Sometimes some of the *Pythium* species appear to act in this way. Other fungi prefer the parasitic life. They are especially to be feared.

Species of grasses differ in their resistance to root rots and crown rots. Sometimes the resistance may be due to some mechanical feature of the plant, such as stout cell walls, but more likely the resistance lies in some chemical antagonism within the cytoplasm of the cell itself. We also have some instances of strain differences in grass species in their tolerance to certain fungi, but in relation to root rots these instances are all too few.

The adaptability of the host to the environment greatly influences its ability to withstand attacks by soil fungi. If the grass, for instance, is a warm-temperature-loving grass from the southern plains, it will often be wiped out by relatively weak soil-borne parasites if sown in cold, wet soil in the northern Great Plains. If the grass prefers a particular soil acidity, it may die from root rots if grown in a place where the acidity is not favorable for the growth of the grass. A desert grass such as Indian ricegrass will soon damp-off or decay if grown in areas of high humidity and frequent rain. Also, grasses that are not hardy are sometimes so weakened that they are more subject to common root rots than are vigorous ones. Winter injury, however, is not a great factor in the ecology of root rot. Much of the injury is to young spring-seeded plants. Injury to older plants is sometimes associated with winter-injured plants or with plants growing in infertile soil. These cases are usually associated with weak parasites, such as certain species of *Fusarium*, *Curvularia*, and *Gloeosporium bolleyi*. Some strains of those fungi, however, are strongly parasitic, so that their presence does not necessarily mean that the root rot injury is on weakened plants.

THE SYMPTOMS the various fungi cause on the host are more interesting

to the general reader than the exact identity of the organisms. We can classify the many rots into a few general groups on the basis of symptoms with a minimum of reference to the causal organism. It is important, however, to know something about the various species and genera of the fungi that cause the rots.

The same organism may cause more than one type of decay. For instance: *Helminthosporium sativum* may cause a seed rot or seedling blight if it occurs on moldy, untreated seed; several years later it may be involved in a crown rot of older plants.

1. *Preemergence rots.* The plant or seed is killed as the seed starts to germinate or just before it emerges from the soil. The rootlets are often rotted to short stubs or collapse in a soft decay. Seed rot in the soil is most frequent in early spring or late fall in cold, wet soil or later in the year if the seed is planted just before a heavy, beating rain. Warm-temperature grasses or grasses with small seeds are especially subject to preemergence rot. The loss of seed from this cause alone averages well above 25 percent of all seed planted. Much of the loss is so common as to be taken for granted.

The most common causes of seed rot are certain species of bacteria and some fungi, including *Pythium debaryanum*, *P. ultimum*, *Fusarium culmorum*, and *Rhizoctonia solani*.

Control of preemergence decay includes the judicious selection of appropriate seeding dates in well-drained soil; the use of viable, clean seed of recent harvest; and seed free from seed-borne molds. The seed should be treated with some seed-treatment material such as Arasan or Ceresan M.

2. *Root necrosis, common root rots, and damping-off.* Sometimes the plants that escape preemergence rots will develop a rapid soft rot and fall over soon after emergence. That is damping-off. Such fungi as *Rhizoctonia solani* and *Pythium debaryanum* are usually the cause of damping-off. Damping-off is common in ornamental and vegetable seedlings but less common in grasses. Sometimes one will encounter damping-off in prolonged rainy periods in thick stands that had emerged earlier during weather that was more favorable.

Grass roots are more likely to suffer from a slower decay, or necrosis. Necrosis due to *Pythium debaryanum* is likely in poorly drained soil or soil saturated by prolonged rains. The roots are often stubbed back by a slow and complete decay. Plants affected with pythium necrosis tend to recover rapidly when good growing conditions return.

The common root rot of maturing cereal plants has its counterpart in grasses. The grass roots are slowly killed by the action of *Fusarium culmorum* or *Helminthosporium sativum* and associated molds, sometimes alone, often competing in the roots of the same host. The *Fusarium* may cause pink or rosy colors on the dead roots, especially at the ground line, where masses of spores form.

Head scab of cereals and sometimes of grasses is caused by *Fusarium* (part of the *F. roseum* complex). This organism or group of organisms can also cause a seedling blight.

The associated fungus *Helminthosporium sativum* causes a brown blotch and root decay of wheatgrasses and, in fact, on many range and pasture grasses. Some seedling blight may result from it. It can also cause preemergence rot when its spores are borne on the seed of grasses raised in areas with high rainfall in summer. Such seed should be treated before seeding. Grass seed grown in the drier western regions, however, are usually free of seed-borne parasitic molds.

3. *Root browning and seedling blights.* In root browning, the root decay is represented by a firm, brown rot, usually of young rootlets. Its action is slow but often deadly. The diseased seedlings gradually fail to keep pace with healthy ones; about 6 weeks after seeding in the spring, they shrivel and die. They soon disappear in the winds

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that sweep across the plains and are replaced by weeds.

The main cause of seedling blight in grasses in the Great Plains and far West is another species of *Pythium* (*P. graminicola*). Its action differs from that of root necrosis caused by *P. debaryanum* in that the plants fail to recover when good weather returns. In fact, the damage often occurs during relatively favorable growing conditions. Some conditions favor its prevalence. It seems to be especially active in grass planted on old plowed sod. It outlasts the bacteria in summer fallow and can only be starved out by several years of continuous fallow. It is possibly less serious on ground that has last grown a crop of corn, oats, or potatoes.

Damage from the root browning fungus is sometimes lessened by the use of a balanced fertilizer that supplies nitrogen and phosphorus to the host and probably to the fungus. The same organism destroys the roots of mature plants in old stands, especially when the stands are sod-bound and have too little nitrogen.

Fall seeding, where practical, is helpful in checking loss from seedling blight. By the following June the plants have passed their most susceptible stage.

Seed treatment does little to check root browning. The sphere of control that seed-borne chemicals can effect is in a small zone close to the seed. Seed treatment helps control seed rot, but it is useless in controlling decay that originates on the rootlets just beyond the old seed.

In South Dakota long search for strains of grasses resistant to seedling blight has resulted in a few strains of grass said to have some tolerance to *Pythium graminicola*.

Other fungi besides *P. graminicola* cause seedling blights, but they are considerably less widespread and less often reach the devastating proportions that this disease assumes. The common root rot *Fusaria*, *Helminthosporium*, *Curvularia*, and *Rhizoctonia* sometimes kill seedlings.

4. *Crown rots, eyespots, and maturity necrosis.* The soil fungi are carried by rain or winds to adjacent crown and stem parts. Sometimes elliptical lesions are formed at the base of the stem. The brown-bordered lesions, pointed at the top and bottom, are called eyespots. The eyespot lesions often form only on the leaf sheath at the base of the stem. *Rhizoctonia solani* sometimes causes eyespots in grasses. In the Columbia Basin of Oregon, Washington, and Idaho, another eyespot fungus, *Cercosporella herpotrichoides*, sometimes spreads from wheat to nearby grasses. Both fungi can work their way through the grass stem and cause a foot rot condition. If the stems break over at this point, the condition is called strawbreaker.

Rhizoctonia solani, one of the causes of eyespot, can produce other symptoms. In closely planted turf its cobwebby mycelium spreads radially, rotting the leaves and forming brown patch areas. We sometimes find brown patch in pastures. Occasionally it also causes some stunting by attacking the roots themselves; then it is often associated with common root rot fungi, and the symptoms are blended in one complex. *R. solani* has at least four races that can be distinguished more or less by their capacity to attack a number of grass, cereal, and leguminous and vegetable crops. One race in western Oregon and Washington is especially virulent on the basal parts of the stems of cereals and some grasses but is scarcely parasitic on legumes. Other races in the Midwest and eastern seaboard are actively parasitic on both grasses and legumes.

Crop rotation to control *Rhizoctonia* is difficult because of its adaptability to numerous hosts and because of the complexity of its races.

CROWN ROTS usually develop on older plants. The interior of the crowns show brown, dry rot. Such plants are probably affected with common rot, the same as occurs in cereals. An abundance of pink *Fusarium* spores

may be present. Sometimes the less conspicuous brown ones of *Helminthosporium* are found.

On Kentucky bluegrass a crown or foot rot occurs. It is caused by a distinct fungus (*Helminthosporium vagans*), which usually attacks the leaves and causes a dark spot.

The roots of plants suffering from crown rots usually are decayed and serve as poor anchors for the plants, which are readily removed from the ground. Old, sod-bound stands especially are subject to crown rots. They also may suffer from root browning, caused by the same fungus that causes seedling blight in young plants (*Pythium graminicola*). Root browning and crown rots often work together in the old stands. Sometimes the plants may be kept producing for a few more years by use of fertilizer to balance the activity of the *Pythium*.

5. *Snow molds*. Some soil-borne fungi attack all above-ground parts of grasses as they lie under the snow in late winter. For many years field workers confused these diseases with winter injury, which is due to low temperature. It has been shown, however, that the elimination of the parasitic mold permitted the plants to survive without injury despite the winter weather. In other words, the parasitic snow mold fungi prefer to live at a temperature approximating that of melting snow.

THERE ARE two common groups of snow mold—the pink snow mold, caused by *Fusarium nivale*, and the speckled snow mold, caused by species of *Typhula*.

Pink snow mold attacks field and turf grasses in late winter, either under the snow or during raw winter weather. The leaves in the prostrate winter rosette stage are killed and formed into pink or straw-colored mats, which later dry to papery films. Sometimes plants recover from the disease if the crowns are not deeply injured. The color of the dead leaves is due partly to the masses of pink spores that are formed. The spores sometimes cause a secondary leaf spot in early spring if cold, wet weather follows melting of the snow.

Pink snow mold is especially common in the Pacific Northwest on cheatgrass brome (*Bromus tectorum*), which serves as one of its carriers.

SPECKLED snow mold, more restricted than pink snow mold, is a true snow mold in that it cannot thrive without the semirefrigeration of melting snow. It causes a slimy, gray rot of grass and cereal leaves under the snow in midwinter or late winter. The gray mold soon forms many tiny, black, hard sclerotia, which dot the white dried leaves after the snow has gone—hence the name speckled snow mold. The sclerotia, which form on the leaves in March to April in the Pacific Northwest, germinate the following November. They produce small, fragile, club-shaped fruiting bodies. The bodies shoot off spores into the air.

Speckled snow mold is controlled by fall applications of mercurials and several organic chemicals, such as PMAS. Chemical control is not at all practical on grasses because of cost, except on greens and other turfs of relatively high value.

HERE is a list of some groups of grasses, their more important diseases, and their general geographic distribution:

Bermuda-grass (*Cynodon dactylon*): Rhizoctonia rot (Southern States).

Bluestems (*Andropogon*): Seedling blight (Great Plains); seed rots (Great Plains).

Brome grasses (*Bromus*): Seedling blight (Great Plains); seed rots (general); snow molds (Northwest and Northeast); rhizoctonia rot (general); common root rot (general).

Dropseeds (*Sporobolus*): Seedling blight (Western States); common root rot (Western States).

Foxtail millet (*Setaria italica*): Seedling blight (general); seed rots (general, North); root necrosis (general).

Grama and buffalo grasses: Seed

rots (Great Plains); seedling blight (Great Plains).

Indian ricegrass (*Oryzopsis hymenoides*): Seedling blight (far West); common root rot and crown rot (far West); rhizoctonia rot (scattered); snow molds (Pacific Northwest); seed rots (general); root necrosis and crown rots (far West).

Kentucky bluegrass (*Poa pratensis*): Dollar spot (Northeast); brown patch (general); foot rot, *Helminthosporium* (general).

Lovegrass (*Eragrostis*): Sometimes seedling blight and common root rot (Southwest and Plains).

Orchardgrass (*Dactylis*): Root necrosis (general); seed rot (general); seedling blight (scattered).

Panicum grasses: Seedling blight (Great Plains); root necrosis (Plains and South).

Redtop and bents (*Agrostis*): Seed rots (general); rhizoctonia rot (general); damping-off (coastal areas).

Ryegrasses (*Lolium*): Common root rot (general); root necrosis (general); rhizoctonia rots (general); seed rots (general).

Timothy (*Phleum pratense*): Seedling blight (general); seed rots (general); root necrosis (general).

Wheatgrasses (*Agropyron*): Seedling blight (Western States); common root rot and crown rot (Western States).

Wild-rye grasses (*Elymus*): Seedling blight (general); common root rot and crown rot (general).

Stipa grasses: Seedling blight (Plains and far West); common root rot and crown rot (Western States).

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Seed Disorders of Forage Plants

John R. Hardison

Seed diseases of forage plants are relatively few, if we do not count the smuts. The four seed disorders I discuss here are different from the seed-borne diseases, in which the causative agents primarily infect leaves, stems, or roots, but also may attack seeds.

Seed diseases are particularly important when they reduce the supply of seed needed to plant forage crops, lawns, or turf. In two diseases—ergot and grass seed nematode disease—the grass seeds are replaced by the sclerotia and galls, which are poisonous to animals.

BLIND SEED DISEASE of perennial ryegrass, *Lolium perenne*, apparently became established in the United States about 1940, although it has been a seed production problem in New Zealand since 1932. Poor germination of seed of domestic perennial ryegrass alarmed growers in Oregon in 1943 and led to positive identification of the disease. But three-fourths of the Oregon crop by then had become infested, and more than one-third of the 1943 seed could not be certified.

The causal fungus, *Phialea temulenta*, was identified in France on cereal rye in 1892, and was identified on perennial ryegrass in New Zealand in 1942. Since then the pathogen has been recognized on perennial ryegrass in England, Ireland, and Scotland; probably it can be found on the grass wherever climate permits infection.