susceptible to root knot nematodes but seldom is damaged by them.

SERICEA LESPEDEZA is a perennial grown throughout the Southeast. It is widely utilized for hay, pasture, soil improvement, and erosion control. Many of the diseases that attack annual lespedeza also attack sericea. None is considered destructive, however, and on the whole sericea lespedeza is quite free from disease troubles. It is somewhat susceptible to root knot nematodes but is not seriously retarded by them.

BIG TREFOIL is a perennial legume. It is well adapted on the low, wet soils in the coastal areas of the entire region and it is planted with grasses for pasture purposes.

Trefoil is susceptible to a foliage blight caused by *Rhizoctonia solani*. Blight is most destructive during the hot, wet summer season on rank, dense growth. Proper management through grazing is the only means of checking extensive damage from the disease. That does not eliminate the fungus from the soil but does check its destructiveness as a foliage disease of trefoil.

Big trefoil is also susceptible to root knot nematodes. It does not suffer extensive damage from them, however, as it is grown on low, wet land; secondary drought effects frequently associated with root knot damage do not occur.

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Leaf Diseases of Range Grasses

John R. Hardison

Of the troubles that beset forage grasses, the leaf diseases are the most numerous and often the most conspicuous. Although one or only a few of them may be serious on a specific grass and their individual effect on grasses may be relatively mild, their total damage can be serious.

Leaves killed by disease become weathered, low in food value, and less palatable for livestock. They cut the quantity and quality of hay and pasture. The weakened plants are less likely to withstand drought and severe winters. Even worse is the result in areas of low rainfall. There grasses may have only one chance to make their season's growth. Disease, by robbing plants of normal leaf growth, can impair the carrying capacity of a range or pasture and reduce the yields of seed to a point where self-propagation or artificial reseeding is retarded.

The more prevalent or striking types of leaf diseases are considered here. We discuss successively those of western grasses, southern grasses, and northern grasses.

WHEATGRASSES (species of *Agropyron*) are prey to at least 70 diseases. More than half are leaf troubles, notably rusts, leaf smuts, leaf blotches and spots, bacterial chocolate spot, scolecotrichum brown stripe, rhynchosporium scald, and powdery mildew.

Powdery mildew is caused by the fungus *Erysiphe graminis*. It occurs

throughout the northern Great Plains and the Pacific Northwest. It usually is more severe in cool, humid, cloudy climates, although it needs little moisture for spore germination. Therefore the disease also survives in drier places and attacks most of the wheatgrasses there, too.

Powdery mildew occurs as white patches on the leaf blades, sheaths, and inflorescences. The fungus is conspicuous, because most of the mycelium and spores are on the surface. Small rootlike organs, haustoria, penetrate the leaf tissue and absorb nutrients at the expense of the plant. Infected leaves turn yellow and brown. The fungus may kill all the leaves in very susceptible grasses. The result is premature dormancy or unthrifty growth of the plant.

New infections start from windborne spores. Within a week new infections produce abundant spores, which spread to other plants. Thus a little powdery mildew rapidly can become an epidemic. The amount of loss it causes in yield of forage has not been determined, but comparable infection in barley has caused a reduction of 30 percent in yield of grain.

Chemical dusts and sprays control powdery mildew, but they are impractical except when grass is intensively grown for seed. The development of resistant varieties of many grasses is possible.

Strains of powdery mildew that infect wheatgrasses have been found on barley, wheat, wheatgrass, and wild-rye grasses. Other mildew strains that attack barley occur on quackgrass (*Agropyron repens*) and a wild-rye grass (*Elymus dahuricus*). Grasses, therefore, can serve as sources of infection of wheat and barley. Other strains of mildew attack only wheatgrasses and wild-rye grasses. The existence of several different mildew races complicates the problem of breeding mildew-resistant wheatgrasses.

Powdery mildew is also prevalent and sometimes destructive on bluegrasses in the Pacific Northwest and northern Great Plains. A similar problem in breeding for resistance exists there, because a number of strains infect different species of bluegrass and strains within the species. Resistant plants in many species of bluegrass are known to exist, however.

Wheatgrasses in dry regions are often free from serious leaf diseases. Lack of moisture and coarse leaf texture may explain why few leaf diseases are important on those grasses.

MEADOW FOXTAIL (*Alopecurus pratensis*) is attacked by at least 15 diseases. The most serious leaf troubles are scolecotrichum brown leaf stripe and rhynchosporium scald.

Meadow foxtail grows throughout the northern Great Plains and Pacific Northwest where enough moisture is available. Growth begins in early spring and is best in cool, moist weather—which also favors maximum development of scald.

Scald, caused by *Rhynchosporium orthosporum*, makes blotches on the leaf blades and sheaths, which at first are water-soaked, ovate to irregular, and scaldlike. The color of the blotches changes from a solid, bluish green to zonated, scalded, and brown zones. Finally the centers become pale. West of the Cascade Mountains in Oregon and Washington the disease develops throughout winter and spring and usually causes much leaf killing. A related fungus, *Rhynchosporium secalis*, damages barley, wheatgrasses, wild-rye grasses, western brome grasses, and sometimes reed canarygrass in the Northwest and the North Central States.

No variety of meadow foxtail is resistant to scald. Crop rotation and attention to sanitation are recommended. Careful spring burning of residues will reduce infection in some areas but would be difficult in regions where the grass grows during the wet winter and spring months.

BLUESTEM, or beardgrass (species of *Andropogon*) is attacked by a great

variety of leaf disorders, including leaf rusts, black choke, anthracnose, cattail, leaf spots, and tar spot.

Tar spot, incited by *Phyllachora luteomaculata*, is of striking appearance. The fungus produces black, sunken, glossy spots on the leaves. Spores produced in organs immersed in these black masses start new infections. Many grasses are attacked by the tar spot diseases caused by similar species of this fungus. Control of tar spot has not been reported. The disease does not kill the grass, and the effect on forage and yields of seed has not been measured.

Septoria leaf spots occur from North Dakota to New Mexico and are occasionally serious. Bluestem grasses generally are subject to more injury from disease in the southern, humid part of their range.

Research to produce disease-resistant varieties of bluestem has been started in Kansas. The Kaw strain of big bluestem, *Andropogon gerardi* (*A. furcatus*), released by the Kansas State College in 1950, is relatively free from disease.

GRAMA GRASSES (species of *Bouteloua*) are subject to 30-odd diseases. In some areas phyllachora tar spot and selenophoma eyespot are important leaf diseases. Leaf rust is often serious. Other leaf disorders include leaf spots, choke, scald, and black ring.

Black ring disease gets its name from the peculiar black organs of a fungus, *Balansia strangulans*, which surround grass culms with a tight collar that strangles the stem and leaves above the fungus body. The seed head is often blighted or is unable to form.

Burning could possibly help control it by destroying the fungus bodies outside the plant and thus eliminating spores that otherwise would be disseminated. New spore organs will arise from the mycelium inside the plant, however.

Seed infection was a problem in the 1930's when efforts were made to reestablish stands of native grasses in midwestern drought areas. Among the native short-grass species used was Fendler three-awn grass (*Aristida fendleriana*). W. W. Diehl, of the Department of Agriculture, inspected some of the seed of that grass harvested in New Mexico for the purpose and found a high percentage of sterile florets infected by *Balansia hemicrypta*. It may be necessary eventually to find disease-free seed when other susceptible grasses are wanted for regrassing programs.

Efforts to breed improved, disease-resistant strains of grama grasses have been started at agricultural experiment stations in Kansas and Oklahoma.

MOUNTAIN BROME (*Bromus marginatus*) and related species are subject to at least 25 diseases. Foliage troubles include several leaf spots, anthracnose, powdery mildew, snow mold, gray leaf spot, tar spot, bacterial chocolate spot, scald, leaf rot, char spot, leaf speckle, brown blotch, brown stripe, rusts, and bacterial blight. Ordinarily the important leaf diseases are scolecotrichum leaf stripe, rhynchosporium scald, and bacterial chocolate spot.

Rescuegrass, *Bromus catharticus*, is subject to fewer and different diseases, including bacterial leaf streak.

Chocolate leaf spot, or bacterial blight, is caused by a bacterium, *Pseudomonas coronafaciens* var. *atropurpurea*. The lesions, circular to elliptical and water-soaked at first, later turn brown and coalesce to form purplish-brown areas on the leaf blade and sheath. Bacterial slime is absent on the surface of the leaf spots. Spots on the panicles are smaller and restricted. In severe attacks the upper nodes may be killed by secondary infections of the organism. In such plants the panicles wither and die, as though injured by frost.

The disease attacks many grasses. It is important on wheatgrasses. We do not know how to control it. The bacteria are believed to overwinter in the lesions on dead grass. Careful burning

before spring growth should reduce the disease.

BUFFALOGRASS (*Buchloë dactyloides*) suffers from 11 diseases. One of them is a leaf and glume spot, frequently called false smut and caused by *Cercospora seminalis*.

The fungus forms a compact, olive-green mass held by the spines that enclose the seed spikelets. Fungus mycelium penetrates the seed and replaces it with a mass of spores. False smut occurs sporadically in dry areas, although it is abundant in wet years. The disease is especially troublesome when buffalograss is grown under irrigation for seed.

Because it reduces yields of seed, false smut has caused a shortage of seed of improved strains. Regrassing programs in which buffalograss is the chief grass used have therefore been retarded. No strains highly resistant to false smut are available, but we hope plant breeding work at several State and Federal stations in the southern Great Plains will develop some.

WILD-RYE GRASSES (species of *Elymus*) are heir to some 75 ills. Common leaf diseases are rusts, leaf smuts, powdery mildew, ascochyta leaf spot, fusarium head blight, phyllachora tar spot, scolecotrichum brown stripe, selenophoma stem speckle, bacterial chocolate spot, septogloeum tar spot, septoria leaf spots, stagonospora purple brown blotch, and epichloe choke or cattail disease.

Cattail disease is named for the whitish body of the fungus, *Epichloe typhina*, which surrounds grass stems with a tight sleeve like the heads of the cattail plant. It occurs sparingly on a large number of grasses in North America. It is sometimes abundant on bluegrasses in the North Central States. Patches of wild-rye sometimes are heavily infested in Northern and Central States. The disease is apparently restricted to sections that have cool seasons and mild winters or in places where the plants are protected by snow. It may severely damage seed-producing stands. It is much more important in Europe than in North America. It is relatively common on prairie junegrass, *Koeleria cristata*, over our prairies and on bluegrasses and wheatgrasses in limited regions.

The fungus produces a perennial mycelium in the crown buds. In summer the mycelium forms a white felt over the surface of late tillers and often covers the seed heads as they emerge from the sheath. The fungus body usually encloses all the seed spike or else parts of the panicle in this type of inflorescence. In late-flowering grasses, such as timothy, tillers may be trapped and delayed or destroyed. As the fungus increases in thickness, it becomes yellow, then orange, and forms the collar around the leaf sheath or stem.

The disease is transmitted in seeds of red fescue, *Festuca rubra*, and possibly in other grasses in which diseased plants produce seed.

The disease was introduced into Pennsylvania in red fescue seeds from Hungary. Growers of grass seed should look for cattail disease in grass-seed crops. With all the present traffic of grass seeds from domestic and foreign sources, this and other diseases could be introduced and become new problems. No adequate control for cattail disease has been developed although roguing is partly successful.

A fusarium head blight has caused serious seed losses in Russian wild-rye, *Elymus junceus*, in New Mexico. Bacterial leaf spots are common on the wild-rye grasses in the northern Great Plains. Powdery mildew is fairly serious on Russian wild-rye in North Dakota.

CANARYGRASSES (*Phalaris* species) have nearly 30 diseases, but most of the leaf diseases are not serious.

Reed canarygrass, *Phalaris arundinacea*, is adapted throughout the Western States, but it grows mainly in locations with abundant moisture,

such as swampy spots, lake shores, and stream banks. Even so, it generally is free of injurious leaf diseases.

A fungus, *Stagonospora foliicola*, causes a tawny spot on leaves. The lesions, which may be brown, wine-colored, tawny, or buff, sometimes cover the entire leaf blade. The disease has been prevalent in late summer at Mandan, N. Dak., in years of abundant precipitation. The trouble was found in plots and native stands in the Missouri River bottom lands and is common in marshes in Minnesota and South Dakota.

Distinct differences in susceptibility of reed canarygrass plants have been noted in upland plots at the Northern Great Plains Field Station—an indication that varieties resistant to the disease are possible.

FIFTY RECOGNIZED PARASITES occur on the western bluegrasses—mutton bluegrass (*Poa fendleriana*), alkali bluegrass (*P. juncifolia*), Nevada bluegrass (*P. nevadensis*), big bluegrass (*P. ampla*), and related species. Their more important leaf disorders are rusts, scolecotrichum leaf stripe, selenophoma leaf spot, septoria leaf spot, and powdery mildew. Control must be sought for by breeding disease-resistant strains of bluegrass.

FOXTAIL MILLET (*Setaria italica*) is subject to cercospora leaf spot, helminthosporium leaf spots, bacterial leaf spots, downy mildew, gray leaf spot, and 17 other diseases.

Gray leaf spot is common on foxtail millets in the United States; it is a minor, but sometimes destructive, leaf spot on many grasses. Severe spotting progresses to a blighting or blasting of the foliage. The causal fungus, *Piricularia grisea*, is like the fungus that causes the blast disease of rice. No control has been suggested for gray leaf spot. Because the grass is an annual plant, crop rotation should help reduce the disease.

Downy mildew, *Sclerospora graminicola*, is probably the most serious leaf disease on foxtail millet in the United States. Affected plants are dwarfed because elongation of culms is retarded. Excessive tillering from the crown and development of branches from the axillary buds along the culm are characteristic. Leaflike malformations of the floral bracts and failure of kernel development are other common symptoms. A downy mass of spores is common on infected plants in humid areas.

Leaf killing and browning are followed by splitting and shredding of the invaded leaf tissues, especially as plants approach maturity. Excessive proliferation of buds and seed heads combined with little or no kernel development causes a serious reduction in yield if infection is high.

Control of downy mildew is difficult in places where those crops are grown continually over large areas because of general soil infestation and wind-borne spores. It is difficult also when the crop is sown in areas where the wild *Setaria viridis* is infected.

Formaldehyde, sulfuric acid, and organic mercury compounds are the best seed treatments.

DROPSEEDS (*Sporobolus* species) are attacked by 36 organisms. Leaf diseases include leaf rust, stem rust, ascochyta leaf spot, bacterial leaf spot, powdery mildew, phyllachora tar spot, selenophoma speckle, cercospora leaf spot, septoria leaf spot, stagonospora leaf mold, and false smut.

False smut or head mold, caused by *Helminthosporium ravenelii*, has a striking appearance. The fungus grows over the seed heads and covers the affected parts with a velvety, brownish-olive mantle, which later becomes black and crusted. Head mold is so common on *Sporobolus indicus* and *S. poiretii* that they are called smutgrasses.

It would be a good thing to treat seed to prevent spread of false smut on infected seed, but that cannot control the disease in infested areas because of contamination by wind-borne spores. Burning might help. The use of re-

sistant varieties seems to be the best solution in places where the disease does great damage.

NEEDLEGRASSES (*Stipa* species) suffer from 50 or more diseases. The more important are septoria leaf spots, selenophoma leaf and stem spots, stagonospora leaf blotch, and scolecotrichum brown stripe.

Brown stripe disease is caused by the fungus *Scolecotrichum graminis*. Young leaf infections show water-soaked, circular or oval lesions, which are olive gray in the morning when they are wet with dew and dull gray when they are dry. The spots become brownish purple to ocher with gray centers. They tend to form streaks as the leaves slowly die. The spore-bearing bodies of the fungus can be seen as prominent, black dots arranged in parallel rows.

Many grasses are affected with brown stripe. The fungus causes one of the most important leaf spot diseases of timothy, orchardgrass, bluegrasses, tall oatgrasses, redtop, and needlegrasses. Early maturity of timothy and some other grasses is often forced by loss of leaves killed by the fungus.

Careful burning of dead grass reduces the spores for infection of new leaves. The relationship of infected wild grasses as sources of infection of domestic grasses needs study. Varieties resistant to the disease are needed in the needlegrasses, tall oatgrass, orchardgrass, and many others.

IT IS HARD TO CONTROL leaf diseases of the range grasses. Extensive application of chemical dusts or sprays is out of the question because of the danger of poisoning livestock. Such materials generally are too expensive for use on forage plants even when land is used intensively for pastures. The cost of treating the many low-producing acres on ranges would be prohibitive.

Crop rotation, clipping, and deep plowing obviously are not feasible for range land. Early or late grazing might remove some infected leaves, but that is not wholly effective because animals avoid badly diseased and dead leaves.

Seed treatment may be helpful in preventing introduction of diseases carried on the seed to new areas in the initial reseeding of range land. Spores of many disease fungi are wind-carried into the new plantings from wild stands, however, and nullify much of the value of seed treatment.

Fire is an effective but dangerous means of destroying diseased leaves. By exercising extreme care and utilizing fire breaks and other precautions to prevent uncontrolled range fires, burning can be a cheap method of reducing initial infection by some diseases. There is, of course, a loss of organic matter and the risk of killing valuable perennial grasses, so that undesirable plants might take over the range lands.

All in all, then, the best way to control most range grass diseases is to use resistant plants. Development of disease-resistant grasses requires exact information on behavior of the disease-producing organisms so that tests for resistance can be performed and understood. Such information is not available for many of the leaf diseases.

A good start has been made, however. Research by many workers has shown which species can be grown in various sections of the country. The identity of the organisms causing many grass diseases has been determined. Disease problems are being further clarified. Prospects are good that more and more adapted, high-yielding, disease-resistant grasses will become available eventually to increase forage on range lands.

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References on leaf diseases of forage crops are given on pages 262 and 267.