Brown Root Rot of Alfalfa

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Since the 1920s, brown root rot (BRR) has been regarded as an important disease of forage legumes, including alfalfa, in northern regions of the North American continent. Brown root rot has been reported in Canada from five westerly provinces, the Northwest Territories, Nova Scotia, and the Yukon, as well as in the U.S. from Alaska and several mainland states. Aboveground symptoms consist of plants that are either slow to green up in the spring or die during the winter. In such instances of "winterkill," stand losses are often assumed to be caused exclusively from exposure to harsh winter weather conditions resulting from extremely cold soil temperatures, ice sheeting, or untimely breaks in plant dormancy. However, we now know that BRR contributes to plant death in Minnesota alfalfa stands in areas where the pathogen is present.

While BRR has been known for many years in North America, until recently the disease was labor-intensive and time-consuming to diagnose. To overcome these difficulties, Minnesota researchers developed a lab assay to detect and quantify the pathogen from plant and soil samples. Scientists in an increasing number of U.S. states and Canadian provinces have used this assay to identify BRR-diseased plants from commercial production fields. Research is ongoing in Minnesota, as well as elsewhere, to understand environmental conditions that promote BRR disease development.

The fungal pathogen (*Phoma sclerotioides*) is relatively dormant during the summer when soil temperatures are warm and other soil-borne pathogens are most active. However, when soil temperatures cool in the autumn, *P. sclerotioides* becomes increasingly active. The pathogen requires cool soil temperatures in which to cause disease. Moreover, it is described as a "snow mold" because its growth is most rapid when soils are covered by snow.

Disease symptoms

If disease development is promoted, substantial stand loss can occur. Such losses can either result during a single winter season or can take place gradually over a number of years. Roots of severely diseased plants can have darkened root lesions from the crown-root junction and below. Root rot is common on diseased tap, lateral, and feeder roots, as well as on the delicate nodule tissues that contain nitrogen-fixing bacteria. Lesions are medium to dark brown and sometimes, but not always, have a thin, darker band around their perimeter. If present, this dark band is a unique characteristic of BRR and is considered diagnostic (**Fig. 1**). If environmental conditions promote disease development, lesions expand asymmetrically, eventually girdling the root.

Fig. 1. Dark-banded BRR lesion visible on tap root just below the plant's crown.

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Diseased plants can survive some root tissue loss (**Fig. 2**), but severe lesions located on the upper tap root usually result in plant death. Good root health at this location is vital to plant survival. Nonstructural carbohydrates and proteins are stored in the upper four to six inches of tap root. This nutrient storage site contains the energy needed to support plant re-growth until adequate leaf tissues establish. If roots are rotted at this critical location, plants will either die or lack vigor for re-growth (**Fig. 3**).

Fig. 2. Secondary tap root has been severed due to BRR. Pycnidia are visible on upper tap root.

Fig. 3. While surviving, this plant's tap root has been severed by BRR.

Conversely, if BRR symptoms do not become severe, diseased plants will likely yield less forage than their healthy counterparts, and may recover to some extent during the growing season. However, symptoms will become increasingly severe on susceptible hosts during subsequent winters, increasing the odds of winterkill.

For guidelines on how to assess alfalfa stand health and density, refer to the joint Univ. of Wisconsin / Univ. of Minnesota Extension publication at http://learningstore.uwex.edu/pdf/A3620.pdf

Distribution

Once thought of as an insignificant disease of alfalfa south of the U.S.-Canada border, recent data refute earlier assumptions. Identified during 1996 in the contiguous U.S. by Wyoming researchers, the disease was detected at about the same time in Montana and later in Idaho. During 2003, diseased plants were identified from commercial production fields in Minnesota and Wisconsin. Shortly thereafter, Minnesota researchers developed a rapid, sensitive assay using quantitative real-time polymerase chain reaction (qRT PCR) to identify and measure the extent of fungal colonization in plant tissues and soils. BRR has now been reported from northeast locations such as New York, Maine, Pennsylvania, Vermont, New Hampshire, and Ontario, Canada, as well as high altitude locations in Colorado and New Mexico (**Fig. 4**). This disease likely occurs in the Dakotas, as well.

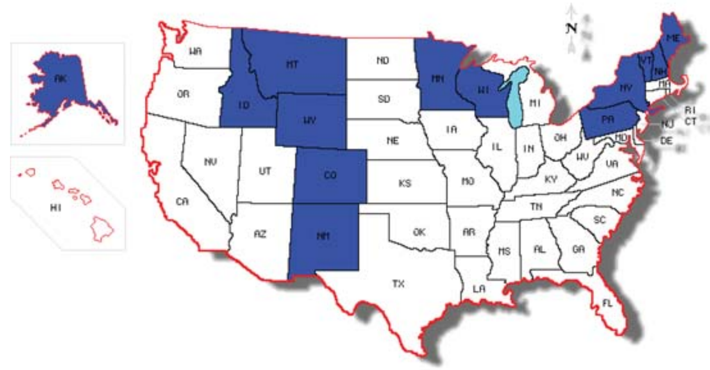

Fig. 4. States where BRR has been reported in the US.

A survey of more than 100 alfalfa production fields in 38 Minnesota and 19 Wisconsin counties netted information about areas with increased prevalence for *P. sclerotioides*. About one-third of the counties surveyed had at least one field in which plants tested positive for the fungus. A higher number of fields were positive for the pathogen from three areas: (1) the Red River Valley in northwestern Minnesota, (2) the St. Croix River Valley in Minnesota and Wisconsin, and (3) west of Green Bay in northeastern Wisconsin (**Fig. 5**). The pathogen is relatively widespread across the two states.

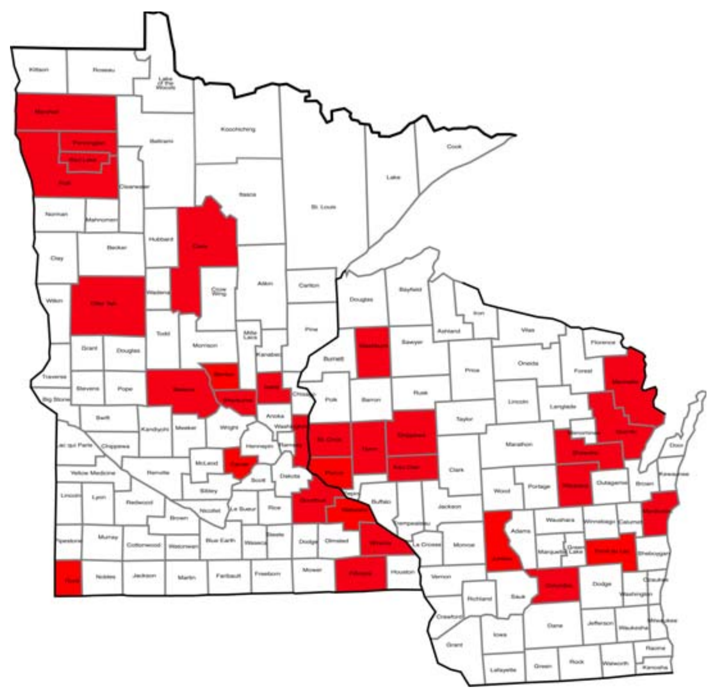

Fig. 5. Minnesota and Wisconsin counties (shaded red) where BRR of alfalfa has been confirmed.

Pathogen biology

Adept at surviving in northern climates, *P. sclerotioides* produces two fungal structures to ensure proliferation in different environments. Shorter-term survival structures, called pycnidia, are slightly embedded in, or superficially attached to diseased plant tissues. As small as a grain of salt, they appear gray to brownish in color and are roughly flask-shaped. One to several appendages (beaks) extend from the body of the pycnidium from which spores (conidia) are released (**Fig. 6**). Occasionally, pycnidia are observed on low-growing, aboveground plant tissues. It is not clear how these fungal structures contribute to the spread of the disease. Longer-term survival structures, called pycnosclerotia, are conidia-free and densely constructed. This structure is produced when the environment is not favorable for disease development. Soil-borne pycnosclerotia germinate when a host root is nearby and environmental conditions promote disease development.

Fig. 6. Microscopic single-celled fungal spores being released from *Phoma sclerotioides* pycnidium.

Mycelial growth and pycnidia production are optimally supported at soil temperatures around 50°F. Fungal growth can occur at lesser or greater efficiencies in soil temperatures ranging from 32º to 81ºF. Host infection is promoted when soil temperatures are cooler, between 35º to 40ºF.

Brown root rot occurs on a number of crops (**Table 1**), and the fungus has been found associated with additional winter cereals, perennial grasses, and biennial hollyhock. An excellent saprophyte, *P. sclerotioides* colonizes residues from crops it attacks as well as those it doesn't (**Table 1**). While a number of weedy plant species have been implicated as hosts of *P. sclerotioides*, tests have not been conducted to determine which weeds are host of the fungus.

Table 1. The fungus that causes BRR survives in diseased host tissues and by colonizing debris from crops that are not live hosts (saprophytic colonization).

Fungal colonization	
Pathogenic & saprophytic	Saprophytic
alfalfa	barley
alsike clover	corn
bird's-foot trefoil	canola
cicer milkvetch	hairy vetch
common clover	oat
red clover	soybean
sainfoin	spring wheat
sweet clover	winter rye
winter wheat	

Symptom similarities

Phytophthora root rot (PRR) is another soil-borne disease that is common and widespread in Minnesota. Loss caused by PRR usually corresponds to field topography. Spread by mobile zoospores, this pathogen causes disease during wet growing seasons and in low lying areas of the field having water-logged soil for extended periods. Root rot lesions appear reddish brown to tan, are soft, and when advanced the disease can girdle and rot tap roots. As the disease progresses, PRR lesions girdle and rot root tissues in an upward direction. This pathogen doesn't produce observable structures on diseased plant tissues and root symptoms lack uniquely diagnostic characteristics. Commercial varieties with resistance to PRR are widely grown. This is not the case for BRR.

Clover root curculio larvae damages young alfalfa stands when populations of the insect become increasingly large. The grub-like curculio feeds on surface tissues of roots leaving open furrow-shaped wounds. Later, tap root tissues appear sunken at old larval feeding sites, much like advanced BRR lesions. Damaged roots often have a darker brown color near feeding sites. This coloring may be the result of secondary fungal and bacterial colonizers.

Winter injury occurs when alfalfa varieties are challenged by severe or extended winter weather conditions beyond their winterhardiness threshold levels. Poor stand management and growing non-adapted varieties are also known to contribute to this issue. Tap roots of winter killed plants appear soft and pliable with slight discoloration near the crown of the plant. Roots are much lighter in color than with either BRR or PRR diseases, and if examined soon after thawing, will not be rotted.

Disease management

Disease management strategies are limited for soil-borne pathogens. Overall, they should focus on maintaining good plant health, particularly as the growing season draws to a close. Minimizing late-season energy expenditures will increase the likelihood that plants will have sufficient energy to survive the winter. This can be done by avoiding excessive harvesting and allowing sufficient foliar re-growth to resupply storage organs following the final harvest and before a killing freeze. Maintaining adequate soil nutrients in plant-available form is essential for a healthy and vigorous stand. For more information on this topic see UMN Extension publication "Fertilizing Alfalfa in Minnesota"
www.extension.umn.edu/distribution/cropsystems/DC3814.html

Similar to other disease issues, an integrated management approach is the best strategy to minimize the effects of BRR in your stand.

Crop rotation

When an alfalfa stand's production declines below what is economically sustainable, the field should be rotated out of susceptible leguminous and grass forage species for up to three years. Avoid corn (grain as well as silage production) or soybean rotations as Minnesota research has shown that *P. sclerotioides* efficiently colonizes debris from both crops, surviving the winters at elevated inoculum levels. Rotating with spring-sown small grain crops such as oat, barley, and wheat reduces inoculum levels, as does fallowing the field.

Resistance

A well-known disease on the Canadian prairies, 'Peace' alfalfa was bred from persistent plants surviving in a BRR-infested field near Fort Vermilion, Alberta, Canada. The variety is BRR resistant, survives harsh, extended winters, and is extremely fall dormant. Its fall dormancy class (FDC) rating is a '1' on a scale of '1' (most dormant) to '11' (least dormant). Its performance potential in the North Central U.S. has not been tested, but is expected to be less favorable compared with locally adapted varieties.

The FDC system is an estimate of the amount of energy varieties partition toward the end of the growing season. The smaller the class ('1' – '4'), the more plant energy is placed into nonstructural nutrient reserve organs before winter. This is not only beneficial for surviving extended winter periods in northerly regions, it is also advantageous if roots become comprised by disease. Unfortunately, a consequence of growing increasingly fall dormant varieties is that less plant energy will be partitioned to support forage production. But, if persistence is an important production goal, less yield potential may be acceptable. Refer to the National Alfalfa and Forage Alliance publication "Winter Survival, Fall Dormancy, and Pest Resistance Rating for Alfalfa Varieties" online at
www.alfalfa.org/pdf/0809varietyLeaflet.pdf
for a complete listing of varieties and their characteristics.

In 1999, researchers from the University of Wyoming began breeding 'Lander', a commercially available BRR resistant alfalfa variety. Lander is less fall dormant than Peace and is adapted to forage production in the arid U.S. under irrigation. This variety has been tested in Minnesota since 2006, but has shown significant stand declines under our conditions.

Tests on 15 commercial varieties grown in Minnesota production fields with damaging levels of BRR indicate that adequate levels of resistance to the disease may already occur in some of our locally-adapted varieties. The following varieties have demonstrated good stand persistence in Minnesota locations with brown root rot pressure: Cal/West 'Velvet,' 'Labrador' and '30-30' (USA) or 'Elevate' (Canada); Dairyland Seed 'msSunstra 536' and 'msSunstra 537'; Forage Genetics 'Integra 8400' and Ameristand '407TQ'; Pioneer HiBred International '54V46,' '55V48,' and '54V09.'

During 2008, breeding efforts were initiated to develop an alfalfa forage variety with known resistance to BRR and local adaptation characteristics. A commercially-available varietal release from this work is not expected for several years.

Chemical control

Fungicide application is not considered to be an effective tool for managing BRR since active ingredient activity is needed in the root tissues of mature plants. Seed treatments or foliar applications of fungicides will not benefit diseased roots.

The pathogen causing BRR of alfalfa is widespread across Minnesota, but disease severity is closely linked with fall to spring weather conditions and stand management. In a worse case scenario, the disease can kill plants from fall through spring. In less severe cases, diseased plants may survive and even recover somewhat depending on their susceptibility level and overall health. Managing crop stressors will help extend the productive life of your diseased alfalfa stands.

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