PLANT DISEASE MANAGEMENT IN SOUTH DAKOTA

Phytophthora Root and Stem Rot (PRR) of Soybean

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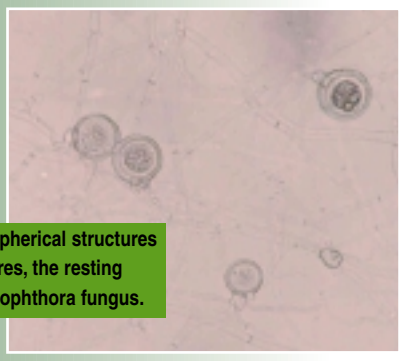

Figure 1. These spherical structures are called oospores, the resting stage of the Phytophthora fungus.

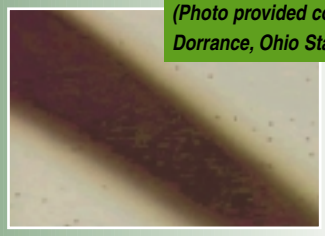

Figure 2. Zoospores are liberated from mature oospores. They swim to soybean roots, diagonal in background of photo, where they encyst and infect. *(Photo provided courtesy of Anne Dorrance, Ohio State University)*

History and impact

Phytophthora root and stem rot (PRR) is currently the most damaging disease of soybeans in South Dakota. Statewide losses from Phytophthora root and stem rot are around 4–6% each year. The impact of the disease is affected by the rainfall patterns in a given year. Sites that receive heavy rains or irrigation may suffer substantial plant mortality and yield losses up to 100% in portions of affected fields.

The pathogen was first reported from Indiana and Ohio around 1950 and has since become widespread and common in the northern states. Crop damage may occur in the first year of planting soybeans at a location.

Biology of the pathogen

Phytophthora root and stem rot is caused by the fungus *Phytophthora sojae*. This fungus is a water mold, or Oomycete. Two types of spores characterize this unusual group of fungi. One spore, called an oospore (Fig. 1) acts as the survival mechanism of the fungus. The thick-walled oospores may persist in soybean residue and soil for many years in the field. Zoospores (Fig. 2) are produced from infected tissue during the growing season. They also are produced when oospores germinate in the presence of a soybean crop. Oospores may remain dormant for many years. Factors that stimulate the oospore to break dormancy and germinate are not well understood. The zoospores are attracted to soybean roots by chemical signals. They swim through films of water to the roots where they infect, and the fungus subsequently grows into and among the root cells of the plant.

Infection is favored in compacted soils and in poorly drained, fine textured, clay soils where temporary flooding may occur and drainage is poor. Typically, soil temperatures must be above 60F for the fungus to germinate and infect.

Successive years of cropping soybeans on the same fields may increase the potential for damage. Studies in Iowa have shown that reduced tillage practices, especially no-till, can increase the potential for damage by maintaining a high concentration of the resting spores of the fungus in the soil layers where the root systems of the new soybean crop will grow. The disease risk is further increased because no-till soils dry out more slowly. High levels of residual nitrogen that may be present where swine manure has been injected into fields will increase the severity of PRR when soil moisture favors infection. This effect may be related to lush plant growth or stress from higher salt content in the soil.

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Symptoms of the disease

Because of the different stages of crop development at which infection may occur, PRR symptoms may vary over the course of the year. The **seed rot** phase of the disease (Fig. 3) may develop if infection occurs after seed swell and before germination. Seeds may rot in the furrow leading to complete disintegration of the seed. Flooding within one week of planting favors early-season diseases such as seed rot and damping-off.

If infection occurs before or within a few days after emergence, the plants may undergo **damping-off,** which is rapid wilting and plant death. Damping-off may occur pre- or post seedling emergence (Fig. 4). Symptoms of the damping-off phase of the disease vary somewhat depending on the degree of resistance in the variety. The symptoms may include yellowing, wilting, and soft decay of the lower stem. Stem tissue sometimes becomes dark and discolored.

The **root and stem rot** phase of the disease typically is observed beginning in July. The fungus invades through the roots and grows into the lower stem. As the disease progresses, symptoms are manifested as a dark-brown discoloration of the lower stem that gradually moves up the plant from below ground level (Fig. 5). Plants will express wilt symptoms with the leaves wilting first and then petioles (leaf stems) drooping, beginning at the bottom of the plant and progressing upward on the stem (Fig. 6). Leaves of wilting plants may develop a grayish cast and then yellowish spots prior to the permanent wilt of the plant.

Later in the season, healthy plants may grow tall enough to conceal plants killed by PRR, making the problem seem less severe (Fig. 7). These plants killed by PRR may only become apparent by spreading the plant canopy apart.

Large areas in lower parts of fields may die off due to the root and stem rot phase of the disease. Weeds typically will colonize the large open areas that result. Weedy areas often are interpreted as weed control failures when the source of the problem was a lack of crop competition due to the plants killed by PRR. Inspection of upland areas may reveal random plants killed by the disease.

Variability of the fungus

Phytophthora sojae occurs in many genetic forms across South Dakota. These forms are known as physiological races. Races of *P. sojae* are determined by specific combinations of virulence and avirulence genes. More than 50 races of the fungus have been identified in North America.

Races 1, 3, 4, and 25, as well as others, are found in South Dakota. Race 1 may be found anywhere in the state but is unimportant when other races are present. Races 3 and 4 are common across the state, but both are not always present in the same fields. Race 25 and other new races were identified in 1998 and, at this time, are present in a limited number of locations.

Figure 3. Seed rot caused by Phytophthora.

Figure 4. Damping caused by Phytop

Figure 5. Note the wilting apparent on plants with the stem rot phase of PRR.

Figure 6. Stem rot phase of PRR. Note the dark discoloration of the basal stem.

Table 1. Shaded cells in the table indicate genes that convey resistance aga

Races of *Phyto*

Race Specific Resistance Gene	1	2	3	4	5	6	7	8	9	10	11	12
1a	■	■								■	■	
1b	■		■	■	■	■	■	■	■			
1c	■	■	■			■	■	■	■	■	■	
1k	■	■	■	■	■	■	■	■	■	■	■	
3	■	■	■	■			■	■		■		
4	■	■	■						■		■	■
6	■	■	■						■		■	■

Managing PRR

Phytophthora diseases, particularly PRR, can be troublesome diseases, commonly resulting in yield losses of up to several percent in South Dakota soybean fields. Through proper crop management and disease monitoring, losses due to PRR can be minimized and low-lying fields or fields with compacted soils can remain productive for soybeans.

No single method can eliminate a problem with PRR in the long run. One approach to management is to correct, in an integrated fashion, the conditions that favor the disease.

DRAINAGE

PRR is favored by wet, heavy, poorly drained, compacted soils. Under compacted soil conditions, *Phytophthora sojae* has been shown to be far more damaging than in well-drained soils (Fig. 8). Similar trends are observed with susceptible, tolerant, and resistant soybean cultivars planted in compacted or well-drained soils. Drainage of soil water is important in the management of PRR. Improving drainage is particularly important in no-till fields where soils dry out more slowly and less rainfall is required to saturate the soil. Phytophthora zoospores are only produced in saturated soils.

CULTURAL PRACTICES

Avoid planting soybean crops on the same field in successive years. Repeated soybean crops can increase the surviving populations of the fungus in the soil. Extended rotation to non-host crops such as corn or small grains will help to maintain manageable levels of Phytophthora.

Avoid spring applications of manure to fields that will be planted to soybeans. High levels of nitrogen and salts associated with manure can increase susceptibility to Phytophthora infection.

Avoid deep tillage with heavy equipment or working soils when they are very wet. This practice can contribute to compaction and the development of compacted plow layers. Tillage practices such as ridge tillage can help dry out wet soil.

VARIETY SELECTION

There are two types of resistance to this disease available in soybean varieties: tolerance (partial resistance or field tolerance) and race-specific resistance. **In fields with known PRR problems or conditions described above that would favor disease, always choose a cultivar with the best tolerance available in the desired maturity group.** Tolerance will not eliminate PRR, but it may delay disease onset, decrease disease severity, and reduce losses due to the disease.

Since there are several races of the PRR fungus in South Dakota, identifying the races present in a field can be helpful for selecting resistant cultivars. Sampling and shipping plants for race testing presents numerous challenges. No race test is presently available in South Dakota, but contact your county extension office to check the current status of the PRR race test in the state.

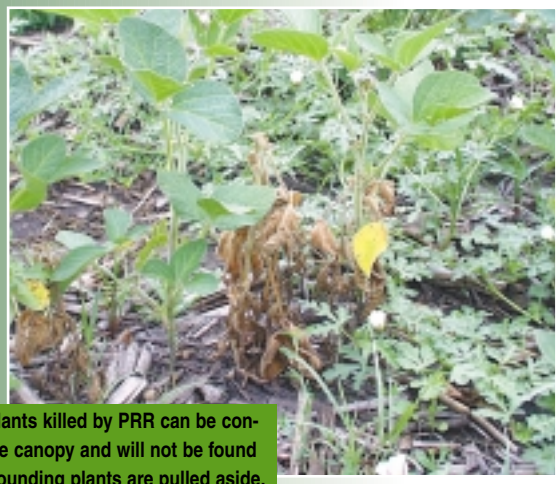
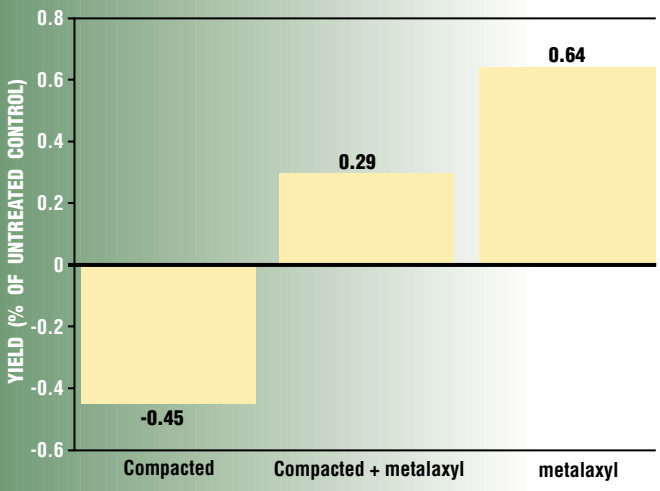


Figure 7. Plants killed by PRR can be concealed in the canopy and will not be found unless surrounding plants are pulled aside. Note the heavy weed growth in this area where PRR has killed many soybean plants.

Figure 8. Effect of compacted soil and metalaxyl on yield of PRR plants.



ainst races 1 through 25 of *Phytophthora sojae*, the PRR pathogen.

ophthora sojae

13	14	15	16	17	18	19	20	21	22	23	24	25
■	■	■	■	■	■						■	
■	■	■		■	■			■	■			
■		■		■				■		■	■	
■	■	■		■	■				■		■	
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			■		■	■	■	■				■
	■	■	■		■	■	■	■				■

When the race of the fungus in a field is known, select a cultivar based on which specific resistance genes the variety possesses. Table 1 describes the race specific resistance that is conveyed by each resistance gene. An indication of the predominant race of *Phytophthora sojae* in a field can be deduced by the performance of resistant varieties in a field. For example, fields planted to a cultivar with the *Rps-1c* gene that still experience significant PRR suggests that race 4 is present and growers should select cultivars in the future with the *Rps-1k* gene. In the absence of testing, growers should employ the Rps-1k gene in a background of good to high tolerance or field resistance for the best performance. A resistant soybean cultivar such as "Dassel," will typically yield much higher than a susceptible soybean cultivar in a Phytophthora-infested field (Fig. 9).

FUNGICIDE TREATMENT

Fungicides also can be used to reduce losses by PRR, but not all fungicides are active against PRR. Only metalaxyl and related fungicides such as mefanoxam and oxadixyl are highly effective against Phytophthora and related water-mold fungi.

Fungicides most often are delivered as seed treatments. When applied to the crop as seed treatments, lower, more affordable rates can be used. Typically a higher seed treatment rate is needed to be effective against Phytophthora than would be used to control Pythium damping-off. Seed treatment products include metalaxyl (Allegiance), oxadixyl (Anchor), and mefanoxam (Apron XL).

Fungicides also can be applied to the soil as a band application over the row. This treatment is rarely used in narrow-row planted beans, because the treatment essentially becomes a broadcast treatment and less affordable. Ridomil Gold is the product used for this treatment. When soybeans are planted in wide rows, band applications of metalaxyl have been shown to be highly effective against PRR. This effect is particularly apparent on compacted soils (Fig. 10).

Photos 1, 3-7 by M. A. Draper

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Figure 9. Effect of PRR on susceptible and resistant soybean cultivars grown on compacted and non-compacted soils.

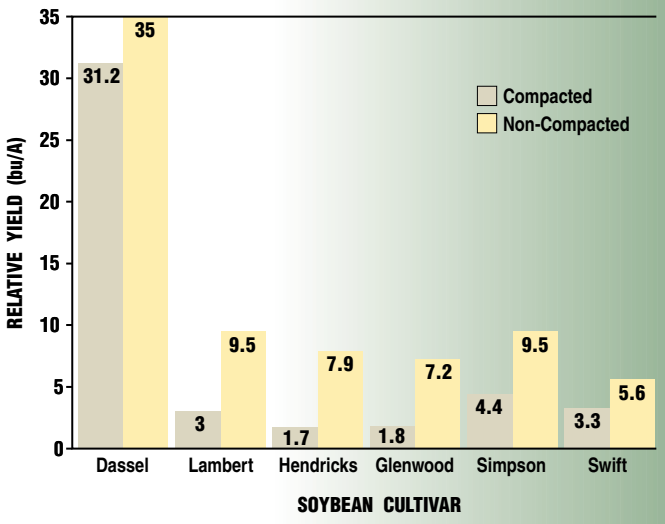

Figure 10. The effect of soil applied metalaxyl in compacted and non-compacted soil in resistant (R), tolerant (T), and susceptible (S) cultivars.