A Pacific Northwest Extension Publication
University of Idaho • Oregon State University • Washington State University

PNW 629

Rhizoctonia on Sugar Beet

Importance, Identification, and Control in the Northwest

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Root rots are the most important limiting factors for the production of sugar beet in many growing areas. The most common root rots are Rhizoctonia root and crown rot, bacterial root rot (*Leuconostoc mesenteroides* subsp. *dextranicum*), bacterial vascular necrosis and rot (*Erwinia carotovora* subsp. *betavasculorum*), Fusarium yellows (*Fusarium oxysporum* f. sp. *betae*), Fusarium root rot (*Fusarium oxysporum* f. sp. *radicis-betae*), Pythium root rot (*Pythium* spp.), and Phytophthora root rot (*Phytophthora* spp.). Since many root rots have similar affinities for environmental conditions, more than one disease can affect the crop in the same field.

Figure 1: Sugar beet field heavily infested with *Rhizoctonia solani*. Photo by Oliver T. Neher

Rhizoctonia solani Kühn, a soilborne fungus, occurs wherever sugar beets are grown and causes major sugar beet losses worldwide. It is estimated that, on average, 2% of yield is lost to this disease annually. However, it is not uncommon to observe 30% to 60% yield losses and even the loss of entire fields (figure 1). In the Treasure Valley of Idaho and in eastern Oregon, the disease has traditionally caused the greatest losses. In recent years Rhizoctonia root rot has increased in Idaho's Magic Valley as well. *Rhizoctonia solani* is also a major component in the Rhizoctonia-bacterial root rot complex, in which the beet root is initially damaged by the fungus and subsequently invaded by the bacterium L*euconostoc mesenteroides* subsp. *dextranicum*.

Figure 2: Rhizoctonia foliar blight as seen under warm, wet weather conditions. Photo by John J. Gallian

The disease is most severe in warm temperatures (70–95 °F, 22–35 °C) in association with wet soil conditions. The causal fungus, *Rhizoctonia solani*, can also cause seedling diseases, primarily as post-emergence damping-off but also as pre-emergence damping-off. Because of cool soil temperatures at normal planting dates, *R. solani* damping-off is a minor problem in the Northwest, and other fungi are usually responsible for seedling disease. However, *R. solani* can cause seedling disease when the crop is replanted at a later planting date when soils are warmer. Under warm, wet weather conditions, Rhizoctonia foliar blight (figure 2) can occur, but it is not considered to be of economic importance in the Northwest.

Although *R. solani* has not been directly implicated as a storage rot organism, roots damaged by this fungus are predisposed to infection by bacteria and other fungi that can cause increased sucrose loss during storage. Secondary infections in the field and the storage pile can lead to hot spots that result in significant storage losses.

SYMPTOMS

Rhizoctonia damping–off

Seedlings infected with *R. solani* show symptoms resembling water soaked, darkened tissue, starting below the soil surface and eventually spreading up to the hypocotyl. Seedlings generally wilt, and they often die.

Rhizoctonia crown and root rot

Two different forms of crown and root rot caused by *R. solani* have been reported. Crown rot (figure 3) infection starts in the crown or on the beet root at or below the soil surface and extends downwards from the point of infection. Infection of the crown is associated with the deposition of soil into the crown by cultivation, wind, or rain.

The infection associated with tip rot starts at the tip of the taproot and moves upward (figure 4). Localized, circular to oval lesions with a dark color coalesce over time.

Foliar symptoms. The first aboveground symptoms for both forms of Rhizoctonia crown and root rot are stunted

Figure 3: Sugar beet showing early (middle) and advanced (left, right) symptoms of crown rot. External symptoms include dark brown to black discoloration of the root surface closest to the crown that moves downward over time. Photo by John J. Gallian

Figure 5: Crown and root rot symptoms can include dark brown to black lesions at the base of infected petioles. Photo by Oliver T. Neher

Figure 4: Sugar beet showing symptoms of tip rot. Symptoms start at the tip of the taproot and move upward. Photo by Oliver T. Neher

Figure 6: Infected petioles remain attached to the crown after they die and form a rosette of dead, brown to black leaves. Photo by Oliver T. Neher

leaf growth, dull leaf color, and a sudden and permanent wilting of the foliage. Wilting is followed by tissue yellowing and death, usually beginning with the older leaves. The base of infected petioles will have dark brown to black lesions (figure 5). Petioles remain attached to the crown after they die and form a black rosette of dead leaves (figure 6).

Root symptoms. General symptoms for crown and root rot include infected root tissue that is dark brown to black (figure 7). As the disease progresses, cankers and cracks may develop deep into the root, commonly on the side of the root or in the crown area. Brown fungal mycelium may be seen in these cracks. The pathogen can also attack the root in multiple areas, which may lead to numerous slightly sunken lesions on the root surface, either with or without small cracks (figures 3 and 4). The margin between healthy and diseased tissue in the interior is sharply defined (figure 7) and will be dark brown to black.

Figure 7: External and internal symptoms of crown and root rot. External infection (at left): infected root tissue is dark brown to black. Internal symptoms (at right): the margin between healthy and diseased tissues is sharply defined. Photo by Oliver T. Neher

Rotted root tissue is firm but may become soft as secondary fungi and bacteria invade (figure 8). Root tissue infected with bacteria will appear in various colors and look wet. In advanced stages of bacterial root rot, cavities, bacterial ooze, and a smell of fermentation will also be present. In the case where secondary fungi and bacteria invade, about 5% of the root mass may be lost to *R. solani*, while subsequent bacterial root rot may take out 20 to 70% of the root mass.

Figure 8: Internal symptoms of crown and root rot. The rotted root tissue is firm but may become soft as secondary fungi and bacteria invade following infection by *Rhizoctonia solani*. Photo by Carl Strausbaugh

Rhizoctonia foliar blight

Foliar blight is rarely seen in Northwest growing areas and might only express itself later in the season under wet and hot conditions as an infection of the rosette. Heart leaves will appear malformed and discolored. As in Rhizoctonia root rot, petioles can exhibit brown to dark-brown cankers. As the disease progresses, pinhead-sized lesions with brown borders will appear on the leaves and expand into larger lesions with a water-soaked appearance and dark green to brown patterns. When humidity decreases, affected tissue dries up and disintegrates, leaving behind leaves that are pitted or in severe cases shredded.

CAUSAL ORGANISM

Rhizoctonia solani occurs throughout the world in agricultural soils and infects many plant species including field crops, vegetables, ornamentals, and weeds.

TERMS ABOUT FUNGI

Hypha
plural: hyphae
Tubular filaments that form the body of a fungus.

Mycelium
plural: mycelia
Mass of interwoven hyphae forming the body or colony of a fungus.

Saprophyte
An organism that feeds on dead organic matter.

Sclerotium
plural: sclerotia
Firm to hard, mostly rounded resting body of a fungus. Consists of compact, interlinked hyphae that are usually dark in color. Can stay dormant in the soil or plant debris for many years.

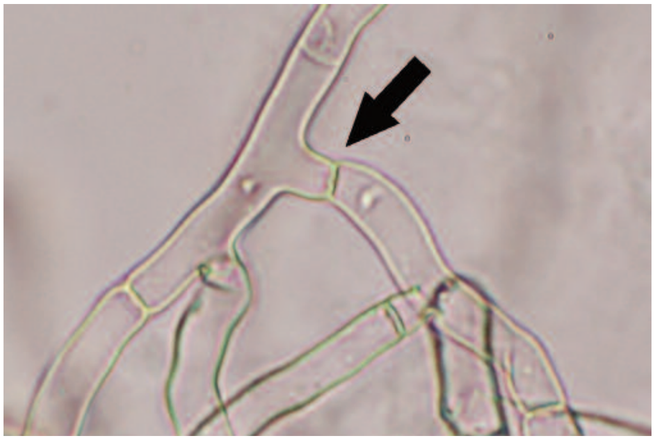

Figure 9: *Rhizoctonia solani* hypha under magnification, showing a characteristic right angle branch (arrow) with a constriction at the branch and a septum within close proximity. Photo by Oliver T. Neher

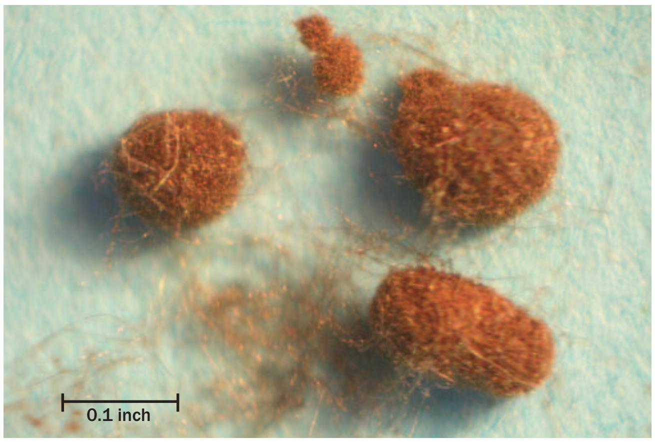

Figure 10: Immature sclerotia of *Rhizoctonia solani*. Sclerotia will change color to dark brown and form a dry, hard, compacted structure with age. Photo by Dragana Budakov

Rhizoctonia solani Kühn is the imperfect (asexual) stage of the sexual spore-producing fungus *Thanatephorus cucumeris* (A.B. Frank) Donk. The sexual stage is rare but occasionally appears on the underside of infected petioles later in the season. Although *R. solani* does not produce spores, its vegetative hypha is quite characteristic and easily identified microscopically. Young hyphae are pale, becoming brown with age. They branch mostly at right angles, usually with a constriction at the branch and a septum within close proximity (figure 9). With age, dark brown, thick-walled, barrel-shaped hyphal cells aggregate to form dry, hard, compacted structures called sclerotia (figure 10). These are visible to the naked eye and allow the pathogen to survive adverse conditions.

Rhizoctonia solani is currently divided into 13 strains, called anastomosis groups (AG) and can be further divided into intraspecific groups (e.g., AG 2-2 IIIB). The various AG strains represent genetic differences within the species. Strains are assigned AGs based on the ability of their hyphae to fuse in culture.

Sugar beets are attacked by strains belonging to AG 2-2 IIIB, AG 2-2 IV, and AG 4. Root and crown rot on mature roots is primarily caused by AG 2-2 IIIB, but intraspecific group IV can also cause some limited damage. Damping-off of seedlings and early foliar blight are generally attributed to AG 4. AG 2-2 can cause damping-off and is suspected to cause foliar blight on mature plants. At the University of Minnesota, Crookston, *R. solani* AG 2-2 IIIB was isolated from edible bean, soybean, corn, and wheat. There is some evidence that potato may be a symptomless host for AG 2-2 and maintain inoculum levels of *R. solani* AG 2-2 in soil.

DISEASE CYCLE AND HOSTS

Rhizoctonia solani survives primarily as mycelium in organic debris, sclerotia in the soil, or on other hosts. Other hosts include weed species like pigweed, lambsquarters, and kochia. In addition, AG-2-2 IIIB can increase on field crops such as corn, edible beans, flax, and canola, while AG-4 may increase on potatoes. Disease severity in sugar beet is related to the population of *R. solani* in the soil, which is increased by cropping systems that include alternate hosts for the fungus.

The fungus can attack any part of the root. It stays inactive below 59 °F (15 °C) but is able to germinate, grow, and infect seedlings and mature plants at temperatures ranging from 59 to 95 °F (15–35 °C). Optimal soil temperatures are between 77 and 91 °F (25–33 °C). In addition, the disease is favored by poor soil structure, and thus it is more common in heavy or compacted soils with high soil moisture.

Rhizoctonia solani is able to survive on living plants, as sclerotia, or as a saprophyte on organic debris. Plant material left in the field after harvest can serve as inoculum for subsequent crops either directly or indirectly by allowing *R. solani* to colonize plant material that is not completely decomposed in soil.

CONTROL

The most effective control measures are those that promote crop health and minimize stress. *Rhizoctonia solani* is a "facultative parasite," in other words, it does not require a living host to develop but will cause disease when conditions are favorable. Various stress factors can predispose sugar beet to infection. These include moisture and nutritional stresses and also insect, nematode, and mechanical injury, which facilitate pathogen entry. Because the environmental conditions suitable for *R. solani* favor several other soilborne diseases, control measures directed toward *R. solani* are usually effective for their control as well.

Early detection of the disease may provide the grower with the opportunity to alter practices and minimize losses. Early detection also allows planning ahead for the next growing season by choosing the right varieties, adapting irrigation and fertilization practices, and implementing fungicide applications.

Cultural practices

Rotation and cropping system. Where Rhizoctonia crown and root rot is minor or non-existent, sugar beet should still be grown in rotation with non-host crops. Sugar beet should be grown in the same field no more than once every year years. Crop rotations should be lengthened to 4 to 5 years where Rhizoctonia crown and root rot has been a problem. Shortened rotations or sugar beet monocultures are the primary causes of the increased yield losses from Rhizoctonia crown and root rot. Shortening the rotation between sugar beet crops or planting alternate hosts leads to the buildup of high soil populations of *Rhizoctonia solani* and other root pathogens. High pathogen populations increase the risk of root rot and render future control more difficult and costly.

Small grains, especially wheat and barley, are the best crops to precede sugar beet and are favored in the rotation for root rot management. Severe losses can occur following beans, corn, potatoes, and alfalfa. Beans host the same pathogen strain (AG 2-2) as sugar beet, and potatoes support populations of AG 4. However, AG-3 is the primary Rhizoctonia strain on potatoes. Significant losses from Rhizoctonia root rot have been experienced in fields that have had long sugar beet rotations but were heavily cropped to beans.

Cultivation and hilling practices. With the introduction of glyphosate-resistant varieties and the increase in sprinkler-irrigated acreages, the need for cultivation has been reduced and only surface-irrigated fields need to be cultivated. Cultural practices that push soil into contact with petioles or into the crowns are one of the most important factors contributing to disease problems since the petioles and crown area are the most common entry points for *R. solani*. The pathogen resides in the soil, and such practices essentially inoculate these susceptible areas and should be avoided, especially where Rhizoctonia root and crown rot has been a problem. Figures 11 and 12 are examples of excessive hilling by a dammer diker in a surface-irrigated field.

Soil compaction. Compacted soil greatly increases the incidence and severity of Rhizoctonia root rot. Soil conditions for optimal plant growth consist of

Figure 11: Example of excessive hilling in a surface irrigated field. Photo by Oliver T. Neher

Figure 12: Example of excessive hilling caused by a dammer diker. Photo by John J. Gallian

approximately 50% solids and 50% pore space. As compaction occurs, the size and number of large pores decrease, resulting in reduced aeration, water infiltration, and drainage. Reducing soil compaction by controlling traffic and wheel tracks, by increasing organic matter, and by planting deep-rooting rotation crops in combination with reduced tillage can be highly successful in reducing *R. solani* and other root rot pathogens. Rhizoctonia root rot problems can be reduced for many growers by using fall bedding, which reduces compaction by eliminating most or all soil preparation in the spring when soils may be wet.

Irrigation. Each irrigation type poses a different set of problems. Surface irrigation will fill the soil profile and does not require frequent irrigation, but it is important to move the water across the field uniformly and in a timely manner (depending on soil texture, in between 12 and 24 hours). Slow or uneven irrigation can lead to waterlogging in the field, which can cause anaerobic soil conditions and favor soilborne pathogens. Anytime furrow irrigation takes close to 24 hours or even longer, the root rot complex will be worse.

Sprinkler and center-pivot irrigation provide uniform irrigation, but require frequent applications that can favor the development of root rot pathogens when the soil isn't given enough time to dry up between waterings.

Many fields are not uniform in soil texture and may tend to dry more quickly in some areas. Irrigating when only a small percentage of the field requires water may result in the majority of the field being excessively irrigated, which favors root rot development. Whenever possible, soil moisture sensors should be used to monitor the majority of the field, and irrigations should be schedule accordingly.

Optimal soil moisture for sugar beet growth is between 40 and 60 centibars (cbars) soil matric potential. Beet should be irrigated when the soil matric potential in the active root zone is about 40 cbars in a sandy soil and 60 to 80 cbars in a silt loam soil.

Studies indicate that sugar beets can be moderately stressed to about 100 cbars with only a minor yield reduction. If root rots have been a problem, scheduling irrigations when soil is slightly dry is preferable. Nevertheless, both wet and dry soil extremes predispose plants to infection and should be avoided.

Crop residues. Crop residues play an important role in the survival and proliferation of *R. solani*. Before planting sugar beet, it is important to uniformly distribute crop residues throughout the soil profile to ensure adequate decomposition by beneficial microorganisms. Adequate soil moisture and nitrogen are required for this process.

Small grains are good rotation crops, but if straw is plowed right after harvest, clumps of buried, nondecomposed straw can be colonized by *R. solani* and potentially increase root rot problems. It is important to avoid colonization of the straw either by chopping the straw and letting it decompose on the surface before plowing it under or by uniformly distributing the straw throughout the soil profile ahead of planting. The longer the interval between plowing and planting, the more the inoculum potential of the straw will be reduced.

Balanced nutrition. Growers should carefully follow fertility recommendations based on annual soil fertility tests. Nutritional stress, whether a deficiency or oversupply, predisposes plants to infection. Excessive nitrogen especially should be avoided.

Plant density. Rhizoctonia root and crown rot is favored by high soil temperatures. Early row closure provided by a well-established and uniform stand is able to shade the soil and reduce soil temperature. An average of 150 plants per 100 feet of row (9-inch spacing) with a 22-inch row spacing is considered optimal, but some growers achieve improved results with closer plant spacing and narrower rows. As plant populations decrease, the probability of *R. solani* infection and disease loss increases.

Weed control. Several weed species, including dandelion (*Taraxacum* spp.), kochia (*Kochia scoparia*), lambsquarters (*Chenopodium album*), pigweed (*Amaranthus retroflexus* L.), and wild oat (*Avena fatua*) are hosts to the pathogen. Effective weed control practices throughout the growing season and during crop rotations are therefore important. Nonhost rotations will not be an effective control tool if weeds are present to support the pathogen.

Chemical and biological control

Chemical control. Fungicides (azoxystrobin, prothioconazole, pyraclostrobin, trifloxystrobin) are available for the control of seedling damping-off and Rhizoctonia root rot. The timing and method of application vary with the form of the disease being targeted. In-furrow application at planting is effective for seedling damping-off, while a banded application before cultivation or at the 4- to 8-leaf stage gives the best control of root rot. Seed treatments for the control of Rhizoctonia damping-off are being tested with promising results.

Biological control. Beneficial microorganisms (*Trichoderma harzianum, Streptomyces lydicus*) have the ability to reduce the severity of *R. solani*, but they are not as effective as fungicides and should be used only in combination with cultural practices and tolerant varieties.

Resistant varieties

Specialty varieties with moderate to strong resistance to Rhizoctonia root rot are available for Northwest growing regions and should be considered in areas with increased disease severity. Nevertheless, some of these varieties might not have the necessary resistance to curly top or Rhizomania, and it is important to comply with the beet cooperative's local requirements. In addition, varieties expressing certain resistance traits might be lower in yield and quality than standard varieties under disease-free conditions, but their usage is justified under moderate to severe disease conditions. The level of resistance to Rhizoctonia root rot expressed by these varieties depends on multiple factors including genetic background, environmental conditions, overall plant health, and good cultural practices.

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Published and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914, by University of Idaho Extension, the Oregon State University Extension Service, Washington State University Extension, and the U.S. Department of Agriculture cooperating.