



# Root and Crown Rots of Small Grains

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Root rots of wheat and other small grains have plagued North Dakota farmers ever since the earliest farming days. The first station botanist at the North Dakota Agricultural College was Professor H.L. Bolley, a plant pathologist. In the early years of this century, Bolley identified root rot of wheat as an important problem and the underlying cause of what was then called "wheat-sick soil." Bolley campaigned across the state for farmers to practice rotation and use good seed. He appeared at county fairs and other gatherings and had posters placed in store windows encouraging farmers to recognize the importance of root rot. Two of his posters are reproduced on the back page of this circular (Figure 5). Their recommendations are still valid some 80 years later!

Root rot damage is seldom recognized until severe damage or death of the crop is seen, because the action of root rot fungi is at or below ground level. Root rot damage is often mistaken for drought injury, soil problems or weather damage.

Most of the organisms which cause root and crown diseases of small grains also attack native grasses, although to a lesser extent. These root rot fungi were probably present in the original prairie soil and are widely distributed throughout North Dakota. While root rot fungi are always present, they may not always cause economic loss, even in a susceptible crop, because many cultural, climatic, and soil factors interact with root rot. On the other hand, a field with a relatively low level of root rot fungi can have significant loss if weather conditions favor disease development and crop stress.

The interactions of root rot with other factors make it difficult for agricultural scientists to accurately predict losses for a given level of disease. Root rot losses in

certain fields in bad years may be very great; losses as high as 50 percent in wheat and 70 percent in barley have been reported for some fields in recent years. The main economic cost of root rot, however, is not such occasional dramatic losses but the constant nibbling away of 5, 10 or 15 percent of the yield, year after year in field after field all across the state.

Actual yield loss measurements made in southern Saskatchewan and Manitoba placed long-term average annual root rot loss at 5 to 6 percent for spring wheat and 11 percent for barley. Measurements across North Dakota record similar findings, with losses in barley at 9.5 percent and losses in durum intermediate between hard red spring wheat and barley.

## Root/Crown Rots of Spring Wheat and Barley

### Common Root Rot

The "common root rot" of spring wheat and barley in North Dakota is caused primarily by the fungus *Cochliobolus sativus*. Other fungi, such as *Fusarium* or *Pythium*, may follow initial *C. sativus* infection and increase the severity of the disease, but these secondary infections are infrequent and often are associated with unusual conditions such as excessive rainfall or high soil temperatures. Outbreaks of root rot caused by *Fusarium*, *Pythium*, or other fungi which act as the primary pathogens may occur in localized areas in some years. In very wet years, take-all root rot may also appear on spring wheat (see section on "Take-All", page 5).

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North Dakota State University, Fargo, ND 58105

FEBRUARY 1995

## Symptoms

*C. sativus* infects roots, crowns and other below-ground parts of the plant. Such infections appear as discrete elongate brown spots or lesions. Infections are especially noticeable on the sub-crown internode and coleoptile but are also found on crowns and roots (Figure 1). When root rot is very severe, the entire crown, sub-crown internode and root system will be dark brown and killed (Figure 2). The stem base also may be discolored dark brown. If such severely diseased plants are pulled from the soil, many of the roots break off because they are decayed.

When root rot is very severe, the destruction of the root and crown tissue may be so great that plants are killed outright, usually during heading and early filling stages. Killing of plants may be severe when hot weather follows cool wet weather. Such killed plants exhibit "early maturity" or "prematurity blight" and the heads frequently appear almost white. Any seed in these heads is shriveled; many heads contain no grain at all. This severe symptom may appear as scattered plants or as patches in the field. When the root rot patches are small (a few yards across) and scattered, they resemble the appearance of salt spots or subsoil sand lenses, with which they are sometimes confused. Examination of the roots and crown of a few plants pulled from such



Figure 1. Diagram of *Cochliobolus sativus* lesions on plants (arrows point to lesions).

a spot show if root rot is the cause of the problem. Prematurity blight of scattered individual plants also is often found when other root-rot fungi such as *Fusarium* or *Pythium* are involved in the complex or when take-all root rot is the cause.

In most fields and in most seasons, the severe root rot symptoms of prematurity blight are not present. This does not mean that root rot is absent, but only that the peculiar combination of weather and soil conditions which promote this very severe disease expression have not occurred. Crops which do not show killed individual plants or patches may still be suffering a reduced yield from root rot.

Where root rot does not kill, it weakens the plant so that it produces fewer tillers and fewer heads, and there is less grain in each head. Grain from root-rotted plants may be shriveled or have a low test weight. Root and crown rot is most severe when wheat or barley are planted continuously without rotation to other crops. Under these conditions, the root rot fungi can build up to very high levels in the soil.

When severe infection by *C. sativus* occurs in the seedling stage, many plants may be killed. This is the "seedling blight" or "post emergence damping-off" phase of the disease (see section on seedling blights).

*C. sativus* may also infect above-ground plant parts under favorable weather conditions. It causes leaf spot on wheat and spot blotch of barley. *C. sativus* leaf spots on wheat are sometimes mistaken for early symptoms of tan spot leaf blight. If heads are infected, the glumes are discolored by the presence of the fungus. Infection of filling grain also can occur, resulting in "black pointed" kernels.

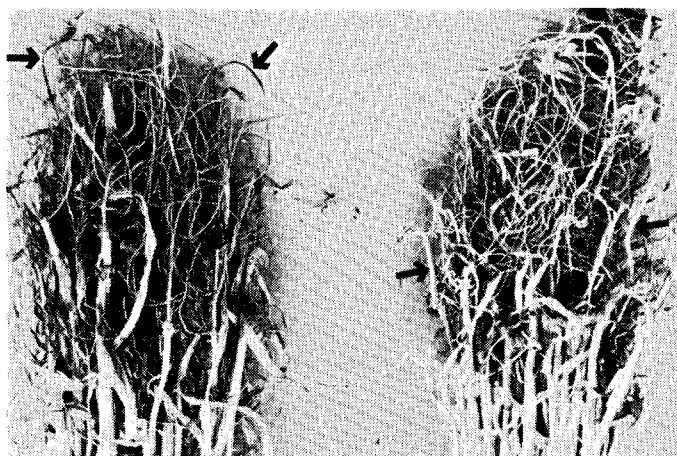


Figure 2. Healthy (L) and root-rotted (R) wheat plants. Arrows point to: white, healthy subcrown internodes (L), and to dark brown, diseased subcrown internodes (R).

## Cause

The common root rot fungus *Cochliobolus sativus* (also called *Bipolaris* and formerly called *Helminthosporium*) survives in the soil or in infected debris from previous crops. Because this fungus survives as spores directly in the soil, it can persist longer than many other root-disease organisms which rely mainly on survival in debris from previous crops. Some *C. sativus* spores remain viable in soil after eight to 10 years. For that reason and because many wild grasses are able to support low levels of the fungus, it is not practical to eliminate *C. sativus* from a field. Fortunately, this is not necessary. After two to three years in non-susceptible row crops, the level of *C. sativus* in soil is significantly reduced, and root rot of grain planted after such a rotation is considerably reduced (see Rotation, in the Management Section).

*C. sativus* spores in the soil infect the growing roots and crowns and cause a discrete lesion or discolored infected spot (Figure 1). Severe disease is the result of multiple infections. The more spores there are in the soil the more lesions will appear. When many lesions are present on the crown and root system, the plant is weakened and yield reduced. New infections continue to arise throughout the growing season, so that crown roots and side tillers also become infected. These lesions can lead to complete decay of the root system.

*C. sativus* may be carried on seed and cause both reduced emergence and more severe seedling blight. The seed-borne infection plays little, if any, role in adult-plant root and crown rot.

## Management

**Varieties.** Commercial wheat, durum and barley varieties vary in their susceptibility to common root rot. None are immune to infection but some have lower and some higher infection levels (Figure 3). Many widely grown varieties are highly susceptible to root rot infection and may exhibit serious losses in bad root rot years. NDSU has an active program to improve root rot resistance in both wheat and barley. Check with your local extension agent or area agronomist for latest information on varietal response to common root rot.

**Rotation.** CROP ROTATION is probably the single most important tool the farmer has to reduce the damage caused by *C. sativus* and other root and crown rots. Rotation to a crop other than wheat and barley may lessen the level of *C. sativus* in the soil, and therefore the level of root rot in the succeeding wheat or barley crops. A fallow period also may reduce the level of *C. sativus* in the soil. The best rotation crops appear to be forage legumes, flax, corn, and hay crops. In some studies, oats in a two-year rotation with wheat or in a three-year rotation with wheat and summer fallow was beneficial in reducing root rot in wheat.

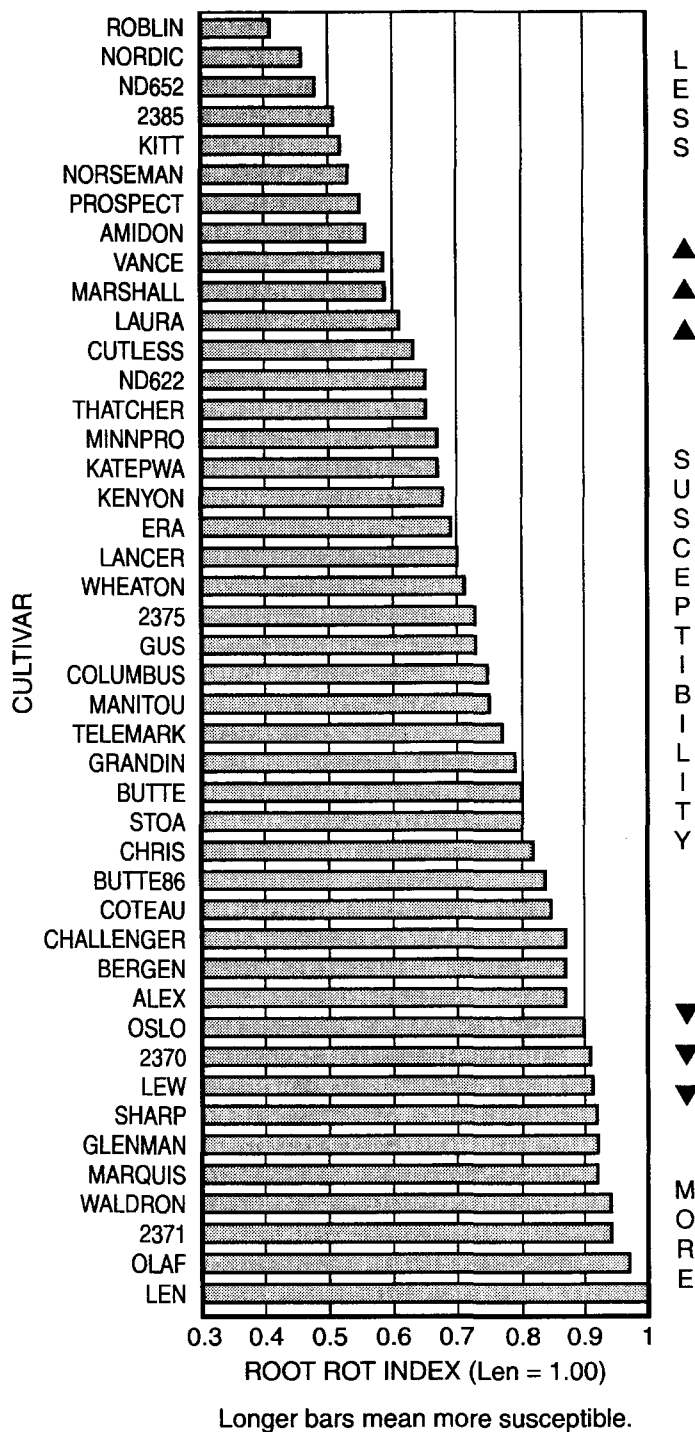


Figure 3. Susceptibility of 44 Hard Red Spring Wheats to Common Root Rot.

More important than the kind of rotational crops is the time between successive wheat or barley crops. A one-year break gives some benefit, a two year break reduces root rot more, and longer periods still more. A four-year rotation aimed at minimizing root rot might be: row crop-oats- summerfallow-wheat or barley. Such a rotation should reduce root rot to a very low level and

could maintain it there indefinitely if continued. Use of such a cropping sequence in a severely infected field to reduce root rot might be followed by a more profitable rotation once the high level of *C.sativus* is reduced.

**Tillage.** Many research studies over the years have examined the effects of tillage type and depth on root rot of wheat or barley. Results show little clear evidence of either adverse or beneficial effects of shallow or deep tillage on root rot. There also appears to be little or no effect of surface residues on root rot, because the fungus survives well in the soil even in the absence of wheat or barley debris. However, in minimum tillage or no-till situations, the level of common root rot may be somewhat reduced because the abundant fungal spores from surface residue are not incorporated into the root zone.

**Soil Fertility.** Adequate nitrogen and potassium levels appear to reduce the severity of common root rot. However excessive fertility levels, especially excessive levels of nitrogen, increase the severity of root rot in wheat and barley. There are some reports that ammonium nitrogen sources may reduce root rot as compared to nitrate nitrogen. Adequate chloride levels (greater than 60 pounds per acre) show some correlation with improved crop tolerance to root rot, but results are not consistent statewide.

**Seed.** Seedling vigor plays a role in determining the effect of root rot on the adult plant. Large, heavy seed produces the most vigorous plants and thereby reduces the effects of root/crown rot, even though the amount of spores in the soil is the same. Black-pointed seed infected with *C. sativus* and scabby seed infected with *Fusarium* will give reduced stands and weaker plants less able to resist the effects of root/crown rot.

**Seed Treatment.** Several seed treatment products are registered for the suppression of common root rot. Imazalil is the common name of one such fungicide, registered for wheat and barley. Trade names of imazalil include Agsco Double R, Nuzone and Flo Pro IMZ. Generally, these products are applied in conjunction with other seed treatment products. Triademefon is the common name of Baytan, another systemic product registered for suppression of common root rot in wheat and barley. Difenconazole is the common name of the seed treatment product called Dividend, registered for the suppression of common root rot in wheat only. Research results have shown these products to significantly reduce common root rot ratings on plants grown from treated vs. nontreated seed. Yield results have been variable, with good yield responses in some cases. The most likely conditions in which seed treatment would be beneficial are: under continuous wheat or barley; where short rotations between susceptible crops occur; and in soils or areas where moisture stress is likely.

## Take-All

Take-all is known throughout the major small grain growing regions of the world. The causal fungus, *Gaeumannomyces graminis*, is found in native prairie grassland soils at low levels. Most of the known cases of take-all disease in North Dakota have occurred in fields of irrigated spring wheat, but it also has been seen in non-irrigated fields in seasons when rainfall has been very high, resulting in high soil moisture. In each case the fields had been cropped to wheat or barley for several successive seasons. Take-all should always be considered a potential threat to irrigated spring wheat or barley in North Dakota and a potential threat to nonirrigated spring wheat or barley after several successive wet years.

## Symptoms

Take-all is a conspicuous disease, easily recognized when it occurs. It is most noticeable from heading time onward. Diseased plants die quickly and are bleached out but remain standing upright. The heads are empty. Diseased plants may be scattered but more often occur in nearly circular dead patches a few to many feet in diameter. The name "take-all" is appropriate for this root disease since the killed plants in the diseased patches have no grain yield. Take-all infected plants are easily pulled from the soil, and if the crowns, basal stems, and roots are examined, they will be a shiny, coal-black color (Figure 4). This coloration is distinct from the dark brown discoloration caused by common root rot. A number of symptoms and signs distinguish take-all root rot from common root rot and from another crown and root rot caused by *Fusarium* (Table 1).

## Management

The risk of take-all buildup can be minimized by practicing good rotation. Do not plant wheat or barley more

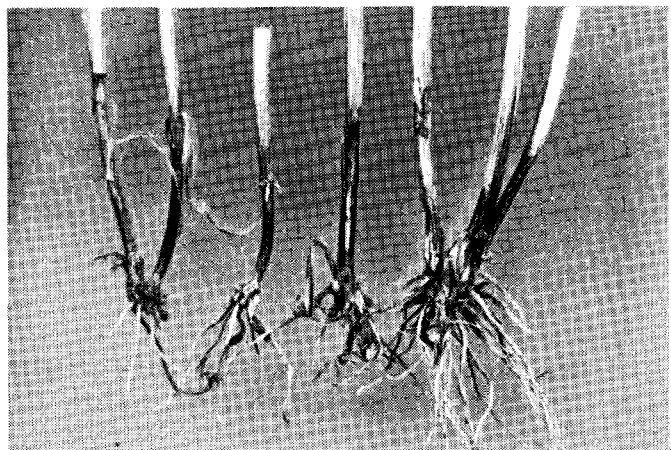


Figure 4. Wheat crowns showing take-all symptoms.

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often than every third year under irrigation. If take-all shows up in a field, the level of the pathogen can be reduced by rotating away from wheat for several years and by burying residues. Maintaining a balanced fertility level and relying on ammonium rather than nitrate nitrogen sources also may reduce the risk of take-all.

In other parts of the country where take-all is a problem, some partially tolerant varieties have been recognized. Wheat or barley varieties have not been examined or selected tolerance to take-all in North Dakota. Two systemic seed treatments, Baytan and Dividend, are registered for suppression of take-all. Dividend is registered for wheat only.

## Fusarium Crown or Foot Rot

Root rots caused by species of the soil fungi *Fusarium* (*Fusarium* crown rot) are occasionally found in North Dakota. Symptoms may appear as reddish-brown decay of root and crown tissue (Table 1). Often these fungi occur along with *Cochliobolus sativus* and aggravate the common root rot symptoms (see above). Management recommendations for *Fusarium* crown and foot rot are the same as for common root rot.

## Other Root and Crown Rots of Spring Wheat and Barley

Several root and crown rots caused by other fungi may sometimes occur in North Dakota. Their appearance is occasional and usually local. The symptoms may resemble common root rot; weak or stunted plants, either singly or in patches; scattered killed plants with bleached empty heads; or a general weakening of plants evidenced by fewer kernels per head or shriveled grain. *Pythium* species may cause a browning root rot of seedlings.

## Management

The same recommendations for common root rot apply to these.

## Root and Crown Rots of Winter Wheat

Several root and crown rot diseases may affect winter wheat. These diseases may act alone or may aggravate hardiness problems, reducing winter survival of plants. Several are most severe under conditions which should favor an otherwise excellent crop (good snow cover, mild winter, adequate moisture). Root/crown disease problems of winter wheat have sometimes been diagnosed as "poor winter survival," or "winter injury."

Diseases of present or potential importance on winter wheat in North Dakota include common root rot and take-all, both discussed under spring wheat, as well as sharp eyespot caused by *Rhizoctonia cerealis*, strawbreaker foot rot caused by *Tapezia yallundae*, snow rot caused by *Pythium* spp., and snow mold caused by *Fusarium nivale* and *Typhula* sp. Not all of these diseases occur every year. Some have only localized importance.

## Strawbreaker and Sharp Eyespot

Strawbreaker foot rot (*Tapezia yallundae*) and sharp eyespot (*Rhizoctonia cerealis*) have not been reported in North Dakota but both are known to occur on winter wheat in eastern Montana and in South Dakota. The pathogens that cause sharp eyespot and strawbreaker foot rot survive in soil debris from previous infected crops. The symptoms of both diseases are distinct lesions on the stem base just above the crown. *Rhizoctonia* may also infect roots. The diseases are most conspicuous following heading. When severe, plants are killed or break over at the base. Large patches of lodged plants may result from this breakage. In less severe cases, side tillers are killed and heads may be shrunken or empty.

## Management

Control depends on good cultural practices as no resistant varieties adapted to North Dakota are known. Late shallow seeding at low stand densities reportedly gives some control and has been used in areas where these diseases are a problem. This practice, however, is not recommended in North Dakota because it might severely reduce winter survival. Very early seeding, before the recommended planting dates for winter wheat, is not recommended; the common root rot fungus is more active at warm soil temperatures, and the chance of infection greatly increases with early planting (see seedling blights of winter wheat). Seed treatment may help by improving stand establishment.

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## Snow Molds of Winter Wheat

Snow mold occurs during the winter and early spring when there is a good snow cover. Snow molds are caused by low-temperature fungi which can grow at near freezing temperatures, when the wheat plants are dormant.

### Causes and Symptoms

Two types of fungal snow molds have been observed on winter wheat in North Dakota. *Fusarium nivale* causes pink snow mold, while species of *Typhula* cause gray or speckled snow mold. Both fungi are able to grow at temperatures at or near freezing under moist conditions, such as occur under melting snow. The snow-mold fungi infect leaves and crowns of wheat plants in the fall under cool wet conditions and remain active during the winter under the snow cover. After snow melt in the spring, the molds are often evident growing over the surface of the plants. If weather in the spring is warm and drying, affected plants will soon recover and losses will be minimal. If cool wet conditions prevail, the fungi can invade the crowns, killing the plants. Snow mold often occurs in patches associated with snow drifts or low areas in fields.

### Management

Snow mold fungi survive in infected debris. Crop rotation – especially to legumes – will break the disease cycle and reduce levels of the pathogens in the soil. Since snow mold fungi require cool, moist conditions, spring wheat can be considered as a rotation crop. Fields with topography or shelterbelts that cause very large, persistent snow drifts may have regular problems with snow mold. No varietal responses are known.

## Seedling Blights of Wheat, Winter Wheat, and Barley

“Seedling blight” is the name given to that phase of root/crown rots which occurs early in the life of the cereal plant. Plant pathologists sometimes call these types of diseases “damping-off” or “post-emergence damping-off.” The symptoms of seedling blight are poor emergence, stunted or weak seedlings and death of seedlings after emergence.

Seedling blight is caused by one or more fungi which may be present in the soil or carried on seed. Fungi which cause seedling blight include *Cochliobolus*, *Fusarium*, *Pythium*, and occasionally others. Seedling blight is more likely to be severe under excessively wet conditions, especially when soil temperatures are too low or too high for good growth. For winter wheat, seedling blight due to *C. sativus* is more likely if soils

remain warm after seeding. This fungus is more active in warm soils, so seeding winter wheat too early increases the risk of seedling blight and root rot.

Seedling blight may be severe because the seed itself is infected by the blight fungi, as is the case with scabby or black-pointed seed. The seed is then the source of the fungal infection, not the soil or the crop residue.

### Management

**Cultural.** Avoid planting in cold, wet soil if possible. Very low soil temperatures retard seed germination, giving blight fungi a better chance to infect. Use plump, heavy, clean seed. Shriveled or broken seed will make weak seedlings which are more susceptible to the attack of pathogenic fungi.

Avoid planting black-pointed seed infected with *C. sativus* or any scabby seed infected with *Fusarium*. The most severely black-pointed or scabby seed will be shrunken, obviously of poor quality and easily avoided by cleaning the seed thoroughly. But some seed which appears normal on casual inspection may carry spores of the seedling blight fungi on it or under the seed coat. These will germinate with the seed and infect the new seedling, causing blight.

**Tillage.** Tillage may affect seedling blight caused by root rot fungi. Since seedling blight occurs while the plant roots occupy only the upper soil layers, any tillage which concentrates residues in upper layers near the surface can increase the incidence of seedling blight. Incorporation of straw and residues deeper into the soil not only improves the physical properties of the soil but also stimulates soil microorganisms which are antagonistic to many root rot pathogens.

**Seed Treatment.** Seed treatment with a fungicide will help protect germinating seed and seedlings from root/crown rot fungi which cause seedling blight. Seed treatment may also kill spores of fungi adhering to seed coats of otherwise healthy seeds. Seed treatment cannot bring “dead” seed back to life but it will improve germination and vigor of poorer quality seed.

Seed treatments will protect the seed against attack from soil-borne or seed-borne fungi under poor seed-bed conditions as well.

Many fungicides are currently registered for seedling blight control in small grains. Some products have systemic activity, moving into the seed, while others are protectants, acting primarily on the seed surface. Some products are a mix of a systemic and protectant to help control both surface and internal pathogens. More detailed descriptions of seed treatments and other diseases controlled by them are contained in Extension Circular PP-447 Rev., “Seed Treatment for Disease Control,” and in Circular PP-622 Rev. “Field Crop

Fungicide Guide.” Read and follow label directions when using seed treatments. Always use proper safety precautions when handling pesticides.

## Root/Crown Rots of Oats

Little is known of the extent of root and crown diseases of oats in North Dakota. The limited reports of disease problems may mean that the diseases are seldom a problem. Oats are generally regarded as tolerant to *Cochliobolus sativus* root rot and often recommended as a rotation crop for wheat or barley. The principal reported root rots on oats are caused by *Fusarium* and *Pythium*. The symptoms of *Fusarium* root rot on oats are similar to those described for common root rot on

wheat and barley. *Fusarium* root rot can be a problem where continuous oats are grown, but this disease is seldom seen when oats are grown in rotations.

Oats are also susceptible to seedling blight caused by *Fusarium*. Control recommendations are the same as for seedling blights of wheat and barley.

### Illustration Credits:

- Figure 1. Judy J. Walker
- Figure 2. H. M. El-Nashaar
- Figure 3. R. W. Stack
- Figure 4. C. R. Grau
- Table 1. R. W. Stack

Table 1. Symptoms associated with three small grain root diseases.

Plant Part Affected	ROOT DISEASE and CAUSE		
	Common Root Rot <i>Cochliobolus</i>	Take-All <i>Gaeumannomyces</i>	Fusarium Crown Rot <i>Fusarium</i>
Crown & Roots	<ul style="list-style-type: none"> <li>• Brown lesions on crown</li> <li>• Roots mostly intact with brown regions visible after washing</li> </ul>	<ul style="list-style-type: none"> <li>• Crown black or gray</li> <li>• Roots brittle, blackened, may break off when plant is dug</li> </ul>	<ul style="list-style-type: none"> <li>• Crown has brown or reddish-brown soft, dry decay</li> </ul>
Sub-crown internode (SCI)	<ul style="list-style-type: none"> <li>• Elongate brown to dark brown lesions on the SCI are diagnostic</li> <li>• In severe cases, the lesions may coalesce, making the entire SCI dark colored</li> </ul>	<ul style="list-style-type: none"> <li>• Not diagnostic; may show gray to black discoloration</li> </ul>	<ul style="list-style-type: none"> <li>• Not diagnostic; may show diffuse browning especially near the crown attachment</li> </ul>
Lower stem base and sheaths	<ul style="list-style-type: none"> <li>• Elongate brown lesions may or not be present</li> <li>• Texture of stem base firm, similar to healthy plant</li> </ul>	<ul style="list-style-type: none"> <li>• Lower stem shiny-coal black</li> <li>• In less severely affected plants, lower stem may appear silvery or metallic</li> <li>• Stem sheaths may show netting of black lines</li> <li>• Blackened stem base is hard like wood</li> </ul>	<ul style="list-style-type: none"> <li>• Lower stem base brown to reddish-brown</li> <li>• Texture of stem base soft, punky, easily crushed between fingers (compare to healthy plant)</li> </ul>
Heads	<ul style="list-style-type: none"> <li>• Fewer tillers, smaller heads, reduced grain fill</li> <li>• Shriveled kernels (white heads may appear but not common)</li> </ul>	<ul style="list-style-type: none"> <li>• White heads in patches, often circular, a few feet to many yards across,</li> <li>• Kernels shriveled or heads empty</li> </ul>	<ul style="list-style-type: none"> <li>• White heads scattered, often only one tiller on a plant is killed</li> </ul>
Environmental conditions favoring infection	<ul style="list-style-type: none"> <li>• Not distinctive</li> </ul>	<ul style="list-style-type: none"> <li>• Higher than normal rainfall</li> </ul>	<ul style="list-style-type: none"> <li>• Warm, dry season for most <i>Fusarium</i> species</li> </ul>

Figure 5. Posters by Prof. H.L. Bolley from 1909 onward to publicize the importance of common root rot. The recommendations are still valid today.

# CROP ROTATION AND DISEASE

4. The reason for Crop Rotation is not particularly to prevent loss of fertility. It is a Sanitary Measure.

PROPER ROTATION Frees the Soil From Specific Crop Diseases.

No Matter How Fertile the Land, you cannot raise heavy seed if the mother seeds carry fungus diseases internally. Flax does this, Wheat does, Oats and Barley do.

Nor can you raise Heavy Seed Wheat if Soil is Wheat-Sick.

Our old Wheat Lands are not "Worn Out"--They are Full of  
Diseased Wheat Roots and Stubble. ROTATE

BOLLEY, N. D. A. C.

# LOST FERTILITY

VS.

## WHEAT ROOT-BLIGHTS

5. We have proved, to our satisfaction, that the SHRIVELLED WHEAT of the Northwest is NOT due to LOST FERTILITY, but to root diseases, often carried internally in the seed, often retained in the soil just as in the Case of Flax wilt

Eventually you will be convinced of this.

BOLLEY, N. D. A. C.

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3M-1-95