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Controlling Root and Crown Diseases of Small Grain Cereals

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Farming systems, equipment, climate, topography, and crops vary widely in the Pacific Northwest. Because of this complexity, managing root and crown diseases of cereal crops is not always simple or straightforward. Recommendations are usually part of a system-wide approach based on the fundamental practices described in this publication.

This information is designed for wheat and barley producers in the Pacific Northwest. Some recommendations can be applied only in wetter areas or irrigated systems, where diverse crop rotations can be used to reduce pathogen populations. Many recommendations are also applicable in low-rainfall, fallow-based systems. Apply as many of the following practices as possible to minimize yield loss and other negative effects from diseases that attack roots, crowns, and lower stems.

Spread chaff and straw during harvest.

Disease management begins at harvest. Piles, clumps, or rows of chaff and straw create cool, moist areas that favor root-infecting pathogens. Use combines equipped with straw choppers and spreaders that distribute residue across the full width of the header.

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Control grass weeds and volunteer cereals.

Grass weeds and volunteer cereals are excellent hosts for root-infecting pathogens. They allow pathogens to survive through the intended "sanitizing phase" (e.g., rotation crop, summer fallow, or overwintering stubble).

Spring cereal yields can increase dramatically in direct-seed systems when seed is planted into fields kept free from grass weeds and volunteer cereals during winter. If possible, apply two applications of herbicide: one application in late fall and the second in early spring. If it is not possible to kill weeds and volunteer cereals during the fall, apply the full rate of herbicide at least 2 to 3 weeks before direct-seeding a spring cereal. Applying herbicide less than 2 weeks before seeding allows root pathogens to grow from roots of the dying weed to seedlings of the emerging, highly vulnerable new crop. The transfer of pathogens and insects from dying or recently killed plants to living plants is called the "green bridge" effect (see sidebar, page 2).

Wheat and barley yields can increase significantly when grass weeds are controlled in broadleaf rotation crops. In fallow, grass weeds usually don't improve pathogen survival when they are killed quickly by rod weeding (conventional fallow) or spraying (chemical fallow). In alfalfa, mint, or other irrigated crops, grass weeds can contribute to the green bridge effect when small grains are planted directly after the broadleaf crop is removed. Controlling grasses in rotation crops also significantly reduces the risk of root diseases caused by fungi and nematodes in the following cereal crops.

Grasses and volunteer cereals are often allowed to grow in overwintering stubble and are almost always infected by root pathogens of wheat and barley. In both conventional tillage and direct-seed systems, it is important to kill grass weeds and volunteer crop species in the fall rather than allow the plants to grow through the winter. In a wheat–fallow rotation, overwintering weeds reduce the sanitizing potential of the 12- to 14-month harvest-to-planting period to an actual host-free interval of only 4 months. In annual spring crop systems, the 7-month harvest-to-planting period is reduced to an actual interval of several weeks if grass-type plants are allowed to overwinter.

Use appropriate seed treatments.

All small grain seed planted in the Pacific Northwest should be treated with a seed protectant to control common bunt, dwarf bunt, flag smut, loose smut, and fungi that cause seedling damping-off.

Winter wheat varieties susceptible to common bunt are planted on most acreage in Oregon and more than 25% of the acreage in Idaho and Washington. In selected regions of each state, significant damage from dwarf bunt must be reduced or controlled using seed treatment and variety resistance. Winter wheat varieties susceptible to flag smut are planted on most acreage in Idaho, Oregon, and Washington. Most spring wheat and barley varieties are also susceptible to loose smut disease.

Before the 1950s, genetic resistance alone could not control smut epidemics. All smuts except dwarf bunt were brought under sustained control only when hexachlorobenzene (a historical use no longer registered in the United States) and then carboxin allowed a combined strategy of genetic resistance plus chemical seed treatment. Dwarf bunt was brought under control when difenoconazole was introduced in the 1990s.

Fungicide seed treatments are relied on more heavily now than at any time in the recent history of small grain production in the Pacific Northwest. Pathogens that cause bunt and smut diseases still are present in the Pacific Northwest, and many current cereal crop varieties are susceptible to one or more of these pathogens. However, most of these diseases cause economic damage only when untreated seed of susceptible varieties is planted.

Prevent the green bridge effect.

The most effective way to prevent diseases and insects from moving from one living plant to another is to extend the time interval when host plants are not present.

From the perspective of a root pathogen, a winter wheat–summer fallow rotation is equivalent to an annual cropping sequence if winter annual weeds and volunteer wheat are allowed to grow for several months or more during the intended sanitizing phase of the fallow.

Likewise, a winter wheat–spring barley–summer fallow rotation is equivalent to double cropping in 2 of the 3 years if volunteer cereals are allowed to overwinter. The inoculum density (number of infective units) of most root pathogens increases in soil and in plant residue as the frequency of host plants increases.

At present, the most common fungicides used to control smut diseases include difenoconazole, prothioconazole, tebuconazole, and triticonazole, each of which is translocated upward to plant tissues above the point where the fungicide is absorbed into the plant. Seed treatments in the Pacific Northwest typically include one of these smut-control fungicides plus other chemicals that reduce damage from seed rot, seedling damping-off, root rot, and insect pests. These chemicals include mefenoxam and metalaxyl to control *Pythium* species, fludioxonil to control *Rhizoctonia* species, and thiram and imazalil to control a wide range of pathogenic fungi. Thiram and imazalil are not systemic—they protect the seed and germinating seedling only from attack by pathogens in soil near the seed.

Insecticide seed treatments are often applied as mixtures with any of the previously mentioned fungicides. Insecticides such as imidacloprid and thiamethoxam reduce damage from wireworms and aphids, including those that transmit barley yellow dwarf virus.

Move infected residue away from the seed zone when planting.

Root pathogens survive mostly in root and crown tissues that were infected while still part of a live, green plant. The quantity (inoculum density) of surviving pathogens declines over time. The rate of decline depends on complex interactions among pathogens, soil organisms, soil moisture, soil temperature, soil chemistry, and the rate of decomposition of dead host tissue. If seed is planted directly into areas with high levels of a surviving pathogen, or if the roots or shoots must grow through such an area, the young, vulnerable seedlings are at high risk of infection.

Reduce the disease risk at planting by using a drill designed to move residue away from the seed zone. Most direct-seed drills with hoe-type openers create a row of dark soil with little or no residue above the seed in an otherwise high-residue, no-till surface. This is sometimes known as the "black ribbon effect." Drills with hoe-type openers are more efficient at moving residue away from the seed row than drills with disk-type openers, but a similar effect can be achieved with disc-type openers by placing a row cleaner or opening coulter at an angle in front of the opener that deposits seed and fertilizer.

Another method for reducing contact between new seedlings and infested root and crown debris is to plant between or diagonal to rows of standing stubble. However, plants will still encounter chaff and other residue on the soil surface that may harbor pathogens.

Band starter fertilizer below the seed.

Starter fertilizer supplements the main fertilizer supply and is placed with the seed, banded below the seed, or banded between rows at planting. Alternatively, starter fertilizer can be broadcast onto the soil surface before planting. An example of a dry fertilizer used as a starter fertilizer is ammonium phosphate sulfate (16-20-0-14) applied at a rate of 10 pounds of nitrogen per acre.

Banding a balanced starter fertilizer below the seed can improve grain yield and plant vigor. Placing fertilizer directly into the seed delivery tube so it remains intermixed with the seed in the soil is less effective but can help crops grow and yield in spite of root diseases. However, because the starter fertilizer can create a salting effect, placing it with the seed can also hinder seed germination and seedling health in drier seedbeds.

Starter fertilizer provides several yield-improving benefits. Nutrients become available to seedlings before they develop an extensive network of feeder roots. Seedlings with immediate access to nutrients are more vigorous and more capable of tolerating early infections by root pathogens. Diseased roots may not reach nutrients banded several inches to the side of the seed row.

Equipment that places starter (or all) fertilizer at least 1 inch directly below the seed also loosens soil and allows the first roots to grow more easily. Roots growing in compacted soil are generally more susceptible to infection because they grow and mature slowly in areas where pathogens are present. Changes in root physiology in compacted soil also increase leakage of organic substances from the roots, making them more attractive to pathogens.

Promote seed germination and healthy seedling growth.

Reduced seedling vigor can reduce yield. Low seedling vigor can occur for several reasons:

- Seed is planted into soil that is too cold, warm, wet, or dry.
- Surface crusting occurs between planting and emergence.
- Seed is damaged—mechanically during harvest and handling, physiologically during storage (stored too long or in hot, moist conditions), or chemically by excessive or uneven application of seed treatments.

Use of fresh seed less than 2 years old is the most important factor affecting seed quality in cool, wet seedbeds. Certified seed provides assurance of seed quality, germination, purity, and genetic identity and has consistently outperformed seed from noncertified sources. Avoid deep planting, which increases seedling stress and predisposes seedlings to infection by Fusarium crown rot pathogens.

Planting spring cereals when the soil temperature is above 50°F can reduce soilborne diseases. Planting earlier, when the soil temperature is below 50°F, increases the risk of take-all, Rhizoctonia root rot (bare patch), and Pythium root rot. However, many planting date studies show that planting earlier can increase yield potential when soilborne diseases are not a problem or are addressed through use of seed treatments, starter fertilizer, and drills that remove residues from the seed row.

Plant winter cereals when the soil temperature at seeding depth is between 45°F and 60°F and when the soil is not too dry or wet. Planting winter wheat into soil warmer than 60°F increases the risk of Cephalosporium stripe, strawbreaker foot rot (eyespot), Fusarium crown rot, and several virus diseases such as barley yellow dwarf and wheat streak mosaic.

Seed germination and seedling growth are optimized when the moisture content of silt loam is between 12% and 18%. If seed is planted into wetter soil, it is important to reduce the pressure on the packer wheels or remove them entirely. Packer wheels are designed to improve seed germination in drier soil. Packing wet soil over newly planted seed reduces the amount of oxygen available to the seed, physically impedes shoot emergence, and creates conditions highly favorable for seed decay and Pythium root rot.

Rotate crops.

Three conditions are required for disease to occur:

1. Virulent **pathogen** in an adequate population (inoculum density) and level of energy (inoculum vigor)
2. Susceptible **host** of the crop species and variety
3. Disease-favorable **environment**

Crop rotation reduces economic damage by minimizing one or more of these conditions. In fact, proper rotation of field crops can reduce pathogen populations almost as effectively as chemical fumigant applications to high-value crops. Rotations should be as diverse as possible to obtain rotational value.

Here are general guidelines for areas with intermediate rainfall:

- Cereal rotated with a broadleaf crop (example: winter wheat and spring canola)
- Winter crop rotated with a spring crop (example: winter wheat and spring barley)
- Different spring or winter crop of the same seasonal growth habit (example: winter wheat and winter barley)

Most pathogens damage only certain groups of plants, such as winter cereals, spring cereals, legumes, or brassicas (Table 1).

Diverse crop rotations minimize the possibility that susceptible plants will be planted in a field infested with a damaging level of pathogens. For some combinations of plants, pathogens, and environments, it is important to avoid planting the same plant species or type (e.g., winter wheat) more frequently than once every 3 years.

Table 1. Hosts and host ranges of common cereal pathogens.

Disease	Host range	Hosts
Cephalosporium stripe	very limited	only cereals
Fusarium crown rot	limited	mostly cereals
Pythium root rot	extensive	most crops and weeds
Rhizoctonia root rot (bare patch)	extensive	most crops and weeds
Strawbreaker foot rot (eyespot)	very limited	only cereals
Take-all	very limited	only cereals
Cereal cyst nematode	very limited	only cereals
Root-lesion nematode	extensive	many crops and weeds

Plant the most resistant species and variety.

Small grain crops differ in their susceptibility to pathogens (Table 2). To reduce problems, plant the most resistant crop species and varieties.

Varietal ratings are available in seed buying guides published annually by agencies such as the Washington State Crop Improvement Association (*http://washingtoncrop.com/buying-guides*). These guides are based on current field observations. Because pathogens and hosts can change in virulence and susceptibility, always use current ratings.

The following paragraphs provide general information about varietal resistance to common cereal crop pathogens. For specific information on these and other pathogens, see the Extension publications listed in the "For more information" section on page 9.

Cephalosporium stripe and strawbreaker foot rot (eyespot) rarely cause economic damage in spring wheat, and winter wheat is more susceptible than winter barley. Some winter wheat varieties have a useful level of resistance to Cephalosporium stripe; some have excellent resistance to strawbreaker foot rot.

Fusarium crown rot occurs on spring and winter cereals. It can damage wheat, barley, and oats. Winter wheat varieties differ in susceptibility. Variations in seasonal weather and the geographic distribution of pathogen species also cause varietal susceptibility to vary across locations and seasons. Specific variety recommendations are not available.

Take-all occurs on wheat and barley planted in fall or spring. An oat-attacking variety of the pathogen may also be present; it affects wheat and barley as well as oat. All varieties are susceptible.

Pythium seed decay, damping-off, and root rot affect all small grains. It is difficult to provide variety recommendations for specific locations because there are many *Pythium* species.

Rhizoctonia root rot (bare patch) is more damaging to spring cereals than to winter cereals, and more damaging to barley than to wheat. Spring barley has the highest risk of infection; winter wheat has the lowest. There are many *Rhizoctonia* species, and each may cause a different symptom on different crop species under different climatic conditions. Current varieties do not have appreciable tolerance or resistance, but resistant varieties are under development.

Spring cereals differ in sensitivity to **nematodes**. For root-lesion nematodes, barley is less sensitive than wheat and also reduces the population of these nematodes in soil. For cereal cyst nematodes, winter wheat is less sensitive than spring wheat, and oats are more sensitive than barley and wheat.

Table 2. Potential for economic loss in small grain cereals.

Disease	Damage potential (highest to lowest)
Cephalosporium stripe	WW > WB >>> SW = SB
Fusarium crown rot	WW > SW > WB ≥ O
Pythium root rot	SW = SB > WW = WB
Rhizoctonia root rot (bare patch)	SB > SW > WB > WW
Strawbreaker foot rot (eyespot)	WW >>> SW
Take-all	SW = SB > WW = WB
Cereal cyst nematode	O > SB = SW > WW = WB
Root-lesion nematode	SW > WW >> SB > WB

Key: spring barley (SB), spring wheat (SW), oats (O), winter barley (WB), winter wheat (WW), greater than or equal (≥), greater than (>), much greater than (>>), very much greater than (>>>).

Root and crown diseases of small grain cereals

Figure 1. Roots invaded by cereal cyst nematode.

Figure 2. Wheat affected by cereal cyst nematode.

Figure 3. Leaf banding caused by Cephalosporium stripe.

Figure 4. Whiteheads caused by Cephalosporium stripe.

Figure 5. Honey-brown discoloration of lower nodes (left) caused by Fusarium crown rot.

Figure 6. Whiteheads caused by Fusarium crown rot.

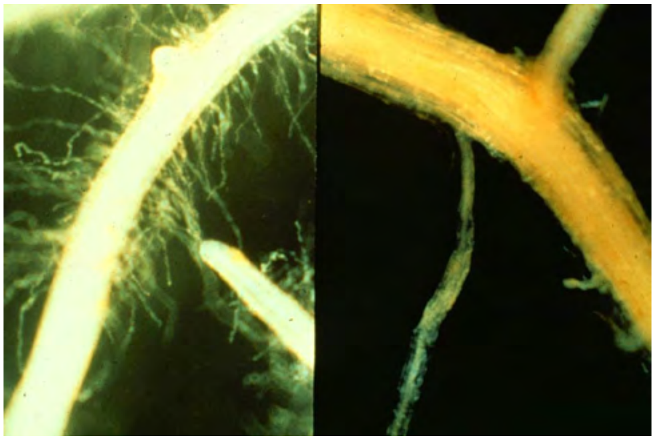

Figure 7. Root hairs on a healthy root (left) and a root affected by Pythium root rot (right).

Figure 8. Pythium damping-off greatly reduced the stand of wheat unprotected by seed treatment (left) compared to the stand grown from seed treated with fungicide (right).

Figure 9. Roots deteriorated by root-lesion nematode (left and right) compared to roots of a resistant wheat landrace breeding line (center).

Figure 10. Root-lesion nematode reduced the plant vigor of wheat unprotected by an experimental nematicide. Note the equal growth of barley in unprotected (left) and protected (right) drill rows.

Figure 11. Crown roots severed by Rhizoctonia root rot (bare patch).

Figure 12. Rhizoctonia root rot (bare patch) of wheat.

Figure 13. Weakened lower stems caused by strawbreaker foot rot (eyespot).

Figure 14. Wheat lodging caused by strawbreaker foot rot (eyespot).

Figure 15. Blackened roots and lower stems and seedling death caused by take-all.

Figure 16. Irrigated wheat with extensive stand failure caused by take-all.

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For more information

Oregon State University Extension Publications

http://extension.oregonstate.edu/catalog

Combatting Take-All of Winter Wheat in Western Oregon. EC 1423. (2008). *http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/19541/ec1423-e.pdf*

University of Idaho Extension Publications

http://www.cals.uidaho.edu/edComm/catalog.asp

Black Chaff of Wheat and Barley. CIS 784. (1986).

High Plains Disease: A New Disease of Corn and Other Cereals in Idaho. CIS 1038. (1996). *http://www.cals.uidaho.edu/edComm/pdf/CIS/CIS1038.pdf*

Scab of Wheat and Barley. CIS 783. (1986).

Seedborne Diseases of Cereals. CIS 833. (1988).

Washington State University Extension Publications

http://pubs.wsu.edu

Reduction of Rhizoctonia Bare Patch in Wheat with Barley Rotation. XB1045E. (2006). *http://cru.cahe.wsu.edu/CEPublications/xb1045e/XB1045E.pdf*

Snow Mold Diseases of Winter Wheat in Washington State. EB 1880. (1999). *http://cru.cahe.wsu.edu/CEPublications/eb1880/eb1880.pdf*

Strawbreaker Foot Rot or Eyespot of Wheat. EB 1378. (2006). *http://cru.cahe.wsu.edu/CEPublications/eb1378/EB1378.pdf*

Pacific Northwest Extension Publications

Available from all three states

Cereal Cyst Nematodes. PNW 620. (2010). *http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/18917/pnw620.pdf*

Dwarf Bunt of Winter Wheat in the Northwest. PNW 489. (1996).

Pacific Northwest Plant Disease Management Handbook. *http://pnwhandbooks.org/plantdisease*

Root-Lesion Nematodes. PNW 617. (2010). *http://ir.library.oregonstate.edu/jspui/bitstream/1957/15119/1/pnw617.pdf*

Viral Diseases of Barley. PNW 493. (1997).

Uniform Combine Residue Distribution for Successful No-Till and Minimum Tillage Systems. PNW 297. (1986).

Use pesticides safely!

- Wear protective clothing and safety devices as recommended on the label. Bathe or shower after each use.
- Read the pesticide label—even if you've used the pesticide before. Follow closely the instructions on the label (and any other directions you have).
- Be cautious when you apply pesticides. Know your legal responsibility as a pesticide applicator. You may be liable for injury or damage resulting from pesticide use.

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