Crown and Root Disease Management Practices for Small Grains caused by Soilborne Plant-pathogenic Fungi

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Outline

• Production of rainfed field crops in the PNW
  – potpourri of issues that influence disease management

• Diseases and disease management
  – overview of chronic diseases in small grain crops
  – seed treatments vs. point of invasion by the pathogen
  – diseases & management vs. ecologic & economic realities on the farm
  – “best-management” practices for controlling multiple diseases
Inland Pacific Northwest
(5.2 million acres of wheat)
Climate at Moro, OR

10.7” mean-annual precipitation (6-17” range)

Precip & Evap (inch/month)

Mean Temp (°F)

Precipitation

Evaporation

4” Soil Temp

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

plant SW

harvest

plant WW
Infective Intervals for Crown and Root Pathogens in Winter and Spring Cereals

**Winter cereals:** 10-11 months from planting to harvest

<table>
<thead>
<tr>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
</tr>
</thead>
<tbody>
<tr>
<td>planting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>harvest</td>
</tr>
</tbody>
</table>

**Spring cereals:** 5-6 months from planting to harvest

<table>
<thead>
<tr>
<th>Sep</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
<th>Jul</th>
<th>Aug</th>
</tr>
</thead>
<tbody>
<tr>
<td>planting</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>harvest</td>
</tr>
</tbody>
</table>

**Infective potential:**
- High
- Minimal
Chemical Seed Treatments: metabolism, degradation, dilution, and zone of protection by acropetal translocation

Surface Protectants
- abamectin, captan, fludioxonil, thiram

Local Systemics
- PCNB

Systemically Translocated
- azoxystrobin, carboxin, clothianidin, difenoconazole, imazalil, imidacloprid, ipconazole, mefenoxam, metalaxyl, prothioconazole, tebuconazole, thiamethoxam, triadimenol, triticonazole
Sites for Infection or Feeding

Likely efficiency of seed treatments:
X = high, X = moderate to low, X = low to none

- Eyespot
- Common root rot
- Wireworm
- Fusarium crown rot
- Pythium root rot
- Rhizoctonia root rot
- Take-all
- Cephalosporium stripe
- Cereal cyst nematode
- Root-lesion nematode
- Common smut
- Covered smut
- Damping-off fungi
- Dwarf bunt
- Seed decay
- Loose smut
- Seed-borne pathogens
Selected cereal diseases caused by soilborne plant-pathogenic fungi

- Smut diseases
- Pythium seed rot and damping-off
- Eyespot
- Rhizoctonia root rot
- Fusarium crown rot & common root rot
- Cephalosporium stripe
- Take-all
Common bunt & Dwarf bunt

Loose smut

Common bunt
## Smut Diseases of Wheat and Barley

<table>
<thead>
<tr>
<th>Disease</th>
<th>Pathogen(s)</th>
<th>Inoculum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common bunt</td>
<td><em>Tilletia tritici, T. laevis</em></td>
<td>✓ external</td>
</tr>
<tr>
<td>Covered smut</td>
<td><em>Ustilago hordei</em></td>
<td>✓ external</td>
</tr>
<tr>
<td>Dwarf bunt</td>
<td><em>Tilletia controversa</em></td>
<td>✓ external</td>
</tr>
<tr>
<td>Flag smut</td>
<td><em>Urocystis agropyri</em></td>
<td>✓ external</td>
</tr>
<tr>
<td>Loose smuts</td>
<td><em>Ustilago tritici, U. nigra, U. nuda</em></td>
<td>internal</td>
</tr>
</tbody>
</table>
The Shifting Strategy for Controlling Smut Diseases

- **Single control practice:** pre-1950’s
  - Resistant varieties
  - Inefficient seed treatments

- **Dual control practices:** 1950’s - 1980’s
  - Resistant varieties
  - Efficient seed treatments
  - Genetic instability
  - Dual practices (genetic + chemical) created a highly stable system

- **Single control practice:** after 1990’s
  - Mostly susceptible varieties
  - Efficient seed treatments
  - Risk of fungicide resistance

In 1997, a survey of seed sold in Montana showed that 2% of them contained ‘background’ levels of the common bunt pathogen.
## PNW Winter Wheat Varieties (in 1994)

<table>
<thead>
<tr>
<th>Origin</th>
<th>Available varieties</th>
<th>Percentage susceptible to:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>common bunt</td>
<td>flag smut</td>
</tr>
<tr>
<td>Oregon</td>
<td>12</td>
<td>58%</td>
<td>83%</td>
</tr>
<tr>
<td>Washington</td>
<td>21</td>
<td>19%</td>
<td>71%</td>
</tr>
<tr>
<td>Private</td>
<td>5</td>
<td>none</td>
<td>80%</td>
</tr>
</tbody>
</table>
# Chemical Control of Smut Diseases

<table>
<thead>
<tr>
<th>Common bunt</th>
<th>Dwarf bunt</th>
<th>Flag smut</th>
</tr>
</thead>
<tbody>
<tr>
<td>* seed-borne</td>
<td>Covered smut</td>
<td>Loose smut</td>
</tr>
<tr>
<td>* soil-borne</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Multiple chemistries are available to provide protection against smut diseases. For current information, seek information from:

1. your seed supplier
2. primary manufacturers
3. ‘Small Grain Seed Treatment Guide’ at [www.msuextension.org](http://www.msuextension.org)
Pythium Seed rot and Damping-off

1. Treat seed with fungicide (metalaxyl or mefenoxam)
2. Plant when germination will be most rapid
3. Place starter fertilizer directly below the seed
4. Control the green bridge
5. Plant fresh seed

difenconazole alone
difenconazole + metalaxyl
Eyespot (Strawbreaker foot rot)  
*Tapesia acuformis & T. yallundae*  
(previously known as *Pseudocercosporella herpotrichoides*)

1. Plant resistant varieties (see the WSCIA seed buyer’s guide or the WSU Extension Bulletin EB1378)  
2. Delay planting date for winter wheat  
3. Plant spring wheat instead of winter wheat  
4. Apply Tilt or Topsin M to foliage if >10% of the winter wheat tillers exhibit lesions during early spring
Rhizoctonia Root Rot

*Rhizoctonia solani* AG-8, & *R. oryzae*

Wheat

Barley

Pea

Canola
Rhizoctonia Root Rot and Yield of Spring Barley: the "Green Bridge" Concept
Smiley, Ogg & Cook (1992)
Controlling Rhizoctonia Root Rot

Before planting:
• Avoid planting susceptible crops annually; crop rotations are not particularly helpful due to the broad host ranges of pathogens
• Control grass weeds and volunteer wheat in over-wintering summer fallow and in rotation crops
• Control the green bridge; spray out volunteer cereals & weeds at least 2-weeks before seed is to be planted
• Use a cultivated fallow rather than a chemical fallow
• Cultivate (rod weed) soil within a few days before planting

At-planting:
• Use a seed drill with a hoe-opener to disrupt soil in the seed row
• Apply starter fertilizer below the seed
• Treat seed, but this improves seedling vigor more often than yield
• Plant when the seed will germinate most rapidly

In-crop:
• No management practices are helpful after the crop is planted
Take-all

Gaeumannomyces graminis var. tritici
Controlling Take-all

Before planting:
• Avoid planting susceptible crops annually
• Control grass weeds and volunteer wheat in over-wintering summer fallow and in rotation crops
• Use a cultivated fallow rather than a chemical fallow
• Avoid a major increase in soil pH if soil needs to be limed

At-planting:
• Manage the form of N that will be absorbed by roots
• Plant when the seed will germinate most rapidly
• Apply starter fertilizer below the seed

In-crop:
• No management practices are helpful after the crop is planted
Crown and Foot Rot Diseases
Fusarium crown and foot rots:

*Fusarium culmorum*

*Fusarium pseudograminearum*  
(= *Gibberella coronicola*)

*Fusarium avenaceum*  
(= *G. avenacea*)

Common root rot:

*Bipolaris sorokiniana*  
(= *Cochliobolus sativus*)
Effect of Planting Date
winter wheat – fallow rotation at Pendleton
F. pseudograminearum  (Smiley, 2009)

Agronomic yield potential:
higher
lower

Disease incidence (%)

September  October  November
Effect of Primary Tillage
winter wheat – fallow rotation at Pendleton
*F. pseudograminearum* (Smiley et al., 1996)
Effect of N Application Rate
winter wheat – fallow rotation at Pendleton
F. pseudograminearum  (Smiley et al., 1996)
Invasion of winter wheat by root-lesion nematodes and a Fusarium crown rot fungus
Hajihassani, Smiley & Afshar (2013)

Many PNW fields are infested with both of these pathogens. This research was conducted in large soil containers in an outdoor nursery over a 2-year period. Winter wheat was grown using natural field planting dates and growing conditions. No supplemental water was applied; water came only from natural rainfall and snow. Disease severity and reduction in grain yield were much greater with dual infections compared to invasion of roots by only one of these pathogens.
Controlling Fusarium Crown Rot

**Before planting:**
- Promote rapid degradation of residue (plow or disk)
- Rotate small grains with summer fallow
- Apply the lowest rate of N fertilizer that will achieve a realistic yield objective; “hard vs soft wheat”, trade-off between full pre-plant application vs. a split application

**At-planting:**
- Apply a seed-treatment fungicide (see [www.msuextension.org](http://www.msuextension.org))
- Plant winter wheat after soil cools to 60°F or lower
- Plant spring wheat when soil warms to 45°F or higher
- When adequate information becomes available, plant the least susceptible varieties to reduce inoculum carry-over (watch for new varieties with parental germplasm from Australia!)

**In-crop:**
- No management practices are helpful after the crop is planted
Cephalosporium Stripe
*C. gramineum*
Controlling Cephalosporium Stripe

Before planting:
- Promote rapid degradation of residue (burn, plow, disk)
- Rotate away from winter wheat for two years
- Correct soil acidity, if it occurs
- Control grass weeds and volunteer wheat in over-wintering summer fallow and in rotation crops

At-planting:
- Plant winter wheat after soil cools to 60°F or lower
- Plant the most tolerant varieties (see seed buyer’s guides)
- Plant spring crops to reduce inoculum density

In-crop:
- No management practices are helpful after the crop is planted
Influence of Conservation Farming Systems* on Diseases of Winter Wheat
Ogg, Smiley, Pike, McCaffrey, Thill & Quisenberry (1999)

<table>
<thead>
<tr>
<th>Disease</th>
<th>No-till</th>
<th>Minimum tillage</th>
<th>Rotation with:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>fallow</td>
</tr>
<tr>
<td>Cephalosporium stripe</td>
<td>↑↓↓</td>
<td>↑</td>
<td>↔</td>
</tr>
<tr>
<td>Crown rot complex</td>
<td>↑↓↓</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Pythium root rot</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Rhizoctonia root rot</td>
<td>↑</td>
<td>↔</td>
<td>↓</td>
</tr>
<tr>
<td>Take-all</td>
<td>↑</td>
<td>↔</td>
<td>↓</td>
</tr>
<tr>
<td>Barley yellow dwarf &amp; Rusts</td>
<td>↔</td>
<td>↔</td>
<td>↔</td>
</tr>
<tr>
<td>Eyespot</td>
<td>↓</td>
<td>↔</td>
<td>↔</td>
</tr>
<tr>
<td>Powdery mildew</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Septoria diseases</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
</tbody>
</table>

* Compared to annual cereals, rotations are likely to increase (↑), decrease (↓), or not change (↔) the level of damage. Tillage comparisons are with respect to inversion plowing or diskig.
### Influence of Conservation Farming Systems* on Diseases of Spring Wheat & Spring Barley

Ogg, Smiley, Pike, McCaffrey, Thill & Quisenberry (1999)

<table>
<thead>
<tr>
<th>Disease</th>
<th>No-till</th>
<th>Minimum tillage</th>
<th>Rotation with:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crown rot complex</td>
<td>↑</td>
<td>↔</td>
<td>↓</td>
</tr>
<tr>
<td>Pythium root rot</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Rhizoctonia root rot</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Take-all</td>
<td>↑</td>
<td>↔</td>
<td>↓</td>
</tr>
<tr>
<td>Barley yellow dwarf &amp; Rusts</td>
<td>↔</td>
<td>↔</td>
<td>↔</td>
</tr>
<tr>
<td>Net blotch</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
<tr>
<td>Scald</td>
<td>↑</td>
<td>↑</td>
<td>↓</td>
</tr>
</tbody>
</table>

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Influence of Conservation Farming Systems* on Some Pests and Parasites of Wheat and Barley
Ogg, Smiley, Pike, McCaffrey, Thill & Quisenberry (1999)

<table>
<thead>
<tr>
<th>Pest or Parastite</th>
<th>No-till</th>
<th>Minimum tillage</th>
<th>Rotation with:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>fallow</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>other crops</td>
</tr>
<tr>
<td>English grain aphid</td>
<td>↑</td>
<td>↔</td>
<td>↔</td>
</tr>
<tr>
<td>Greenbug</td>
<td>↓</td>
<td>↓</td>
<td>↔</td>
</tr>
<tr>
<td>Hessian fly</td>
<td>↑↓</td>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td>Wireworm</td>
<td>↔</td>
<td>↔</td>
<td>↓</td>
</tr>
<tr>
<td>Root-lesion nematode</td>
<td>↔</td>
<td>↔</td>
<td>↓</td>
</tr>
<tr>
<td>Cereal cyst nematode</td>
<td>↔</td>
<td>↔</td>
<td>↓</td>
</tr>
</tbody>
</table>

* Compared to annual cereals, rotations are likely to increase (↑), decrease (↓), or not change (↔) the level of damage. Tillage comparisons are with respect to inversion plowing or disking.
Best management approach for controlling multiple diseases: “the over-reaching principles”

- Spread the chaff and straw while harvesting
- Rotate cereals with summer fallow or “program crops”
- Plant the most resistant or tolerant variety available
- Control over-winter grass weeds and volunteer cereals
- Treat seed with protectant chemicals
- Band starter fertilizer below the seed while planting
- Move infested residue from seed zone when planting
- Promote seed germination and healthy seedling growth