

Diagnosing and Managing Diseases of Wheat

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WSU Wheat Academy
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WASHINGTON STATE UNIVERSITY
College of Agricultural, Human,
and Natural Resource Sciences

2

Fungal Diseases of Wheat in the PNW

Common name	Pathogen
Stripe rust	<i>Puccinia striiformis</i>
Eyespot	<i>Oculimacula yallundae</i> , <i>O. acuformis</i>
Cephalosporium stripe	<i>Cephalosporium gramineum</i>
Rhizoctonia root rot	<i>Rhizoctonia solani</i> , <i>R. oryzae</i>
Fusarium foot rot	<i>Fusarium culmorum</i> , <i>F. pseudograminearum</i>
Fusarium head blight (FHB)	<i>Fusarium graminearum</i> and others
Pythium seed/root rot	<i>Pythium</i> spp.
Snow molds	<i>Typhula ishikariensis</i> , <i>Microdochium nivale</i>
Stem rust	<i>Puccinia graminis</i>

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3

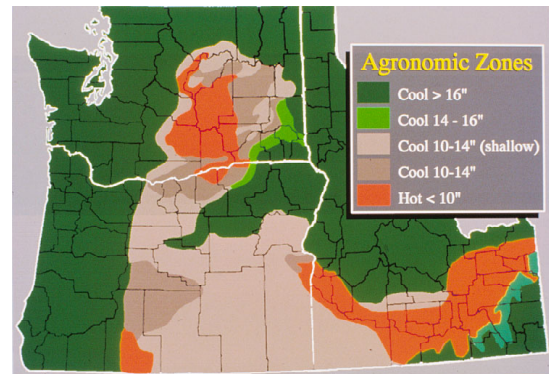
Virus & Bacterial Diseases of Wheat in the PNW

Common name	Pathogen
Barley yellow dwarf	<i>Barley yellow dwarf virus</i> , <i>Cereal yellow dwarf virus</i>
Black chaff	<i>Xanthomonas translucens</i>
Soilborne wheat mosaic	<i>Soilborne wheat mosaic virus</i>
Wheat streak mosaic	<i>Wheat streak mosaic virus</i>

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4

PNW Agronomic Production Zones



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5

Distribution of Diseases by Rainfall				
Disease	Rainfall zone			
	8-12"	12-18"	>18"	Irrig.
Stripe rust				
Eyespot				
Cephalosporium stripe				
Rhizoctonia root rot				
Fusarium crown rot				
Fusarium head blight				
Snow molds				
Soilborne wheat mosaic				
Wheat streak mosaic				

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6

Management Considerations			
Disease	Cultural practices	Variety selection	Chemical control
Stripe rust	+	+	+
Eyespot	+	+	+
Ceph. stripe	+	+	-
Rhizoctonia root rot	+	-	-
Fusarium crown rot	+	-	-
Fusarium head blight (FHB)	+	-	+
Pythium root rot	+	-	+
Snow molds	+	+	-
Soilborne wheat mosaic	-	+	-
Wheat streak mosaic	+	-	-

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7

Cultural Management Practices						
Disease	Seeding date	Residue mgt	Green bridge	Fertility	Crop rotation	Soil pH
Stripe rust	+	-	+	+	-	-
Eyespot	+	+/-	-	-	-	-
Ceph. stripe	+	+/-	-	-	+	+
Rhizoctonia	+/-	+	+	-	-	-
Fusarium	+	-	-	+	-	-
FHB	-	+	-	-	+	-
Pythium	+	+	+	-	-	-
Snow molds	+	-	-	-	-	-
SBWM	+	-	-	-	-	-
WSMV	+	-	-	-	-	-

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8

Stripe Rust



USDA-Cereal Disease Lab

T. Lumpkin, CIMMYT

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9

Stripe Rust



Courtesy X. Chen

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10

Factors Affecting Stripe Rust

Temps of 50-64°F w/6 hrs of dew

- cool temps most important for infection
- disease development up to ~90°F

Fall infection

- susceptible plants in fall

Winter survival

- temperatures during Dec-Feb

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11

Stripe Rust Outlook – December 2023

What we know now:

- Rust developed later in the 2023 season and was followed by below average precip in fall
- typical planting & emergence + Fall weather = average risk for rust establishment
 - ➔ Still very early
- December & January temperatures will determine rust survival into 2024
 - ➔ Expect Dr. Chen's 1st forecast in January

12

Stripe Rust Control Options

Cultural

Green bridge management

Avoid early planting

Avoid excessive irrigation (furrow better than sprinkler)

Plant disease resistant varieties

➔ preferably those with HTAP resistance (1-4)

Monitor rust forecast, scout fields, spray fungicides when necessary

➔ Scout fields for rust, spray susceptible varieties (5-9) or when 1-5% of plants have active rust

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13

Stripe Rust Resistance - Winter Varieties 2023

Rating	Varieties
R (1,2)	aMaze, AP Dynamic, AP Exceed, AP Iliad, AP Octane, Appleby CL+, ARS Castella, ARS Crescent, ARS-Selbu 2.0, Bobtail, Bruehl, Cameo, Cara, Inspire, Jameson, Jasper, Kairos, LCS Artdeco, LCS Blancor, LCS Blackjack, LCS Drive, LCS Evina, LCS Hulk, LCS Jefe LCS Rocket, LCS Shark, LCS Shine, LCS Sonic, LCS Yeti, LCS Zoom, M-Press, Nimbus, Nixon, Norwest 553, Norwest Duet, Norwest Tandem, OR2x2 CL+, Resilience CL+, Rosalyn, Sockeye CL+, SY Assure, SY Banks, SY Clearstone CL2, SY Dayton, SY Ovation, SY Raptor, VI Bulldog, VI Frost, VI Presto CL+, WB1529, WB1604, WB1720, WB4311, WB4510CLP, WB4623CLP
MR (3,4)	AP Redeye, AP Venom, ARS Selbu, Coda, LCS Ghost, LCS Helix AX, Mela CL+, Millie, Pritchett, Stingray CL+, TMC M-Pire, UI Bronze Jade, UI-WSU Huffman, WB1376CLP, WB1621
M (5)	AP503 CL2, Guardian, GS Bounty, LCS Aymeric, Mary, Otto, Piranha CL+, Puma, SY107, SY Command, SY Touchstone, UI Castle CL+, UI Sparrow, WB1783, WB4394
MS (6,7)	AP700 CL, AP Legacy, Canvas, Curiosity CL+, Devote, Irv, Keldin, LCS Fusion AX, Milestone, Purl, Scorpio, Sequoia, UI Palouse CL+, WB1532, Whistler
S (8,9)	Battle AX, Brawl CL Plus, CP7010, CP7909, LCS Jet, Snowmass 2.0, UI Magic CL+, VI Voodoo CL+, WB4303, WB Rimrock Soft white, Hard red, Club, Hard White WSU Wheat Academy 2023

14

Stripe Rust Resistance - Spring Varieties 2023

Rating	Varieties
R (1,2)	Alum, AP Octane, AP Renegade, Chet, CP3055, CP3066, CP3099A, CP3119A, CPX39120, Dayn, Espresso, Glee, Hale, JD, Melba, Seahawk, SY Basalt, SY Gunsight, SY Teton, Tekoa, TMC2021, TMC Lochaven, WB6121, WB7202CLP, WB9636, WB9662, WQL008, WQL195, YSC-605
MR (3,4)	Cabernet, CP3322, Diva, Hedge CL+, LCS Iron, Net CL+, Roger, Ryan, SY Coho, SY Selway, SY Steelhead, UI Platinum, UI Stone, SY Saltese, WB9668, UI Cookie, YSC-603
M (5)	AP Coachman, AP Venom, Buck Pronto, Bullseye, Louise, WB6341, Whit
MS (6,7)	AP Mondovi CL2, Hollis, Jefferson, Jefferson HF, LCS Luna, Kelse, WB9303, WB9623
S (8,9)	Babe, CP3530, SY605 CL2, WB1035 CL+, WB6211CLP Soft white, Hard red, Club, Hard White, Durum

Variety ratings courtesy of Dr. Xianming Chen, USDA-ARS

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15

Fungicides

Monitor forecasts and development of rust

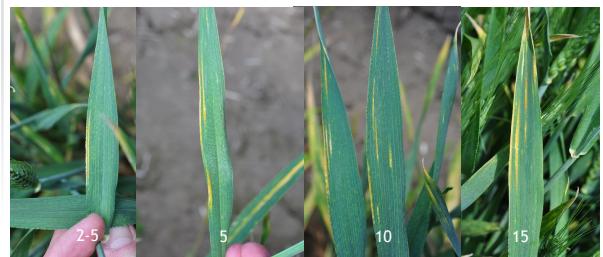
Spray when necessary:

Spray when susceptible varieties (5-9) have 1 to 5% rust

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16

What Does 5% Rust Look Like?



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17

Rust Fungicides - 2023

Class	Active ingredient	Product	Rate/A, fl. oz	Stripe rust*	Head scab	Harvest Restriction
Strobilurin	Picoxystrobin 22.5%	Aproach SC	6.0 - 12.0	E	NL	Feekes 10.5
	Pyraclostrobin 23.6%	Headline SC	6.0 - 9.0	E	NL	Feekes 10.5
	Azoxystrobin 22.9%	Quadris 2.08 SC**	4.0 - 12.0	E	NL	Feekes 10.5.4
Triazole	Metconazole 8.6%	Caramba 0.75 SL	10.0 - 17.0	E	G	30 days
	Tebuconazole 36.7%	Folicur 5.6 F**	4.0	E	P	30 days
	Prothioconazole 41%	Proline 480 SC	5.0 - 5.7	VG	G	30 days
	Prothioconazole 19%	Prosaro 421 SC	6.5 - 8.2	E	G	30 days
	Tebuconazole 19%	Tilt 3.6 EC**	4.0	VG	P	Feekes 10.5.4
	Propiconazole 41.8%	Sphaerex	4.0 - 7.3	E	G	30 days
	Metconazole 10.91%					
	Prothioconazole 18.19%					
Mixed modes of action	Tebuconazole 22.6%	Absolute Maxx SC	5.0	VG	NL	35 days
	Trifloxystrobin 22.6%					
	Cyproconazole 7.17%	Aproach Prima SC	3.4 - 6.8	E	NR	45 days
	Picoxystrobin 17.34%					
	Prothioconazole 16.0%	Delaro 325 SC	8.0	VG	NL	Feekes 10.5
	Trifloxystrobin 13.7%					
	Pydiflumetofen 13.7%	Miravis Ace SE	13.7	VG	G	Feekes 10.5.4
	Propiconazole 11.4%					
	Fluxapyroxad 2.8%	Nexicor EC	7.0 - 13.0	E	NL	Feekes 10.5
	Pyraclostrobin 18.7%					
	Propiconazole 11.7%	Priaxor	4.0 - 8.0	VG	NL	Feekes 10.5
	Fluxapyroxad 14.3%					
	Pyraclostrobin 28.6%					
	Prothioconazole 17.39%	Prosaro Pro SC	10.3-13.6	E	G	30 days
	Tebuconazole 8.7%					
	Fluopyram 8.7%					
	Propiconazole 11.7%	Quilt Xcel 2.2 SE**	10.5 - 14.07	E	NL	Feekes 10.5.4
	Azoxystrobin 13.5%					
	Prothioconazole 10.8%	Stratego YLD	4.0	VG	NL	Feekes 10.5
	Trifloxystrobin 12.3%					
	Benzenodiflupyr 2.9%	Trivapro SE	9.4 - 13.7	E	NL	Feekes 10.5.4
	Propiconazole 11.9%					
	Azoxystrobin 10.5%	Topguard EQ	4.0-7.0	E	NL	Feekes 10.5.4
	Flutriafol 18.63%					
	Azoxystrobin 25.30%					30 days

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Eyespot



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Eyespot Lodging



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Factors Affecting Eyespot

Autumn temperatures 40-50°F

Rainfall

Snow cover

→ December 2023 outlook:

- Similar to stripe rust: normal planting & emergence + below average rainfall + mild temperatures = average risk for susceptible varieties
- Scout fields of susceptible varieties prior to jointing to determine severity

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Control of Eyespot

Cultural practices

→ seeding date

Resistant varieties

Foliar fungicides

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22

Eyespot Resistant Winter Varieties

- Cara
- Devote*
- Dyna-Gro Impact
- Inspire*
- Jasper
- LCS Blackjack
- LCS-Drive
- LCS Hulk*
- **LCS-Jet**
- Madsen
- M-press
- Nixon
- Norwest Tandem
- OR2X2
- Otto
- Piranha CL+*
- **Pritchett**
- Resilience CL+
- Rollie*
- Rosalyn
- Sockeye CL+*
- Stingray*
- SY Raptor
- **SY Touchstone**
- VI Bulldog
- VI Frost
- WB 1529
- WB 1604
- Windust*

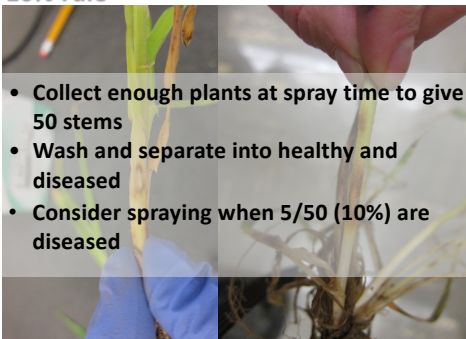
Soft white, **Hard red**, **Club**
*based on molecular marker data

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23

When to Spray?

"the 10% rule"



- Collect enough plants at spray time to give 50 stems
- Wash and separate into healthy and diseased
- Consider spraying when 5/50 (10%) are diseased

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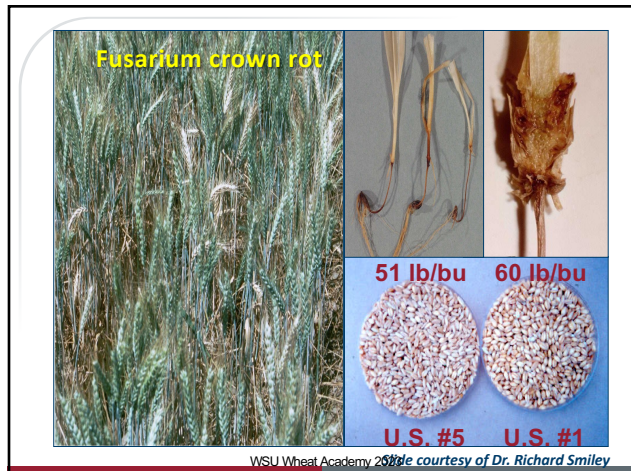
24

Eyespot Fungicides

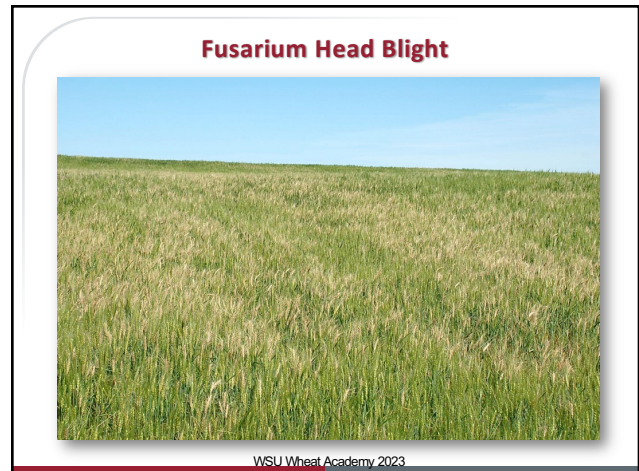
Active Ingredient	FRAC Group	Product	Rate/A, fl. oz	Application
propiconazole	3	Tilt 3.6EC**	4.0	Up to Feeke's GS 6
thiophanate-methyl	1*	Topsin 4.5 FL	10.0	
propiconazole	3	Quilt Xcel 2.2 SE	14.0	Up to GS 6
azoxystrobin	11	Topsin 4.5 FL	10.0	
thiophanate-methyl	1*			
cyproconazole	3	Alto 100 SL	3.0-5.5	Up to GS 6
thiophanate-methyl	1*	Topsin 4.5 FL	10	
fluxapyroxad	7	Nexicor EC	9.0-13.0	Up to GS 10.5
pyraclostrobin	11			
propiconazole	3			
fluxapyroxad	7	Priaxor	6.0-8.0	Up to GS 10.5
pyraclostrobin	11			
pydiflumetofen	7	Miravis Ace SE	13.7	2EE label
propiconazole	3			

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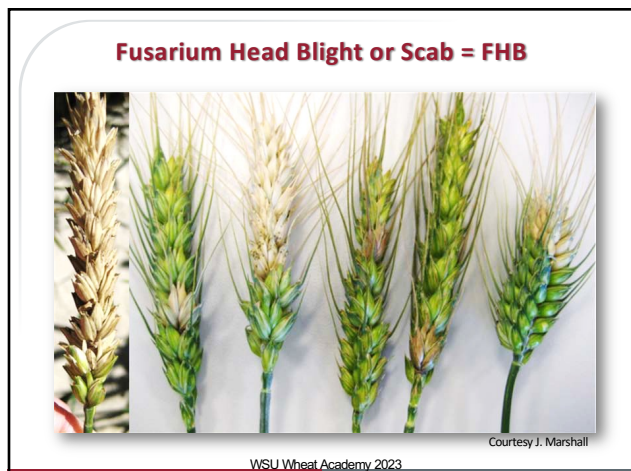
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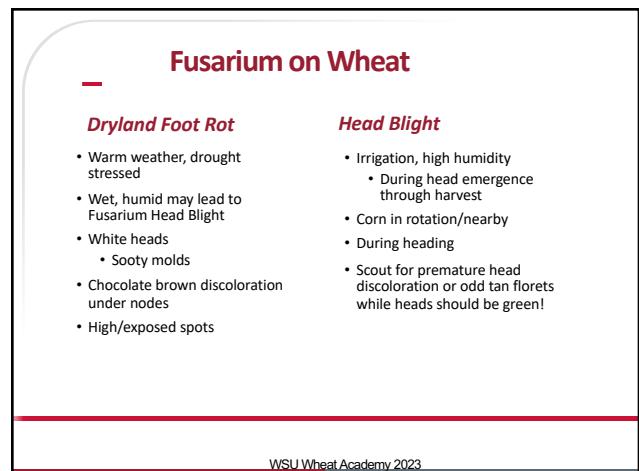
26



27



28



29

Fusarium on Wheat



Dryland Foot Rot

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30

Signs & Symptoms FHB

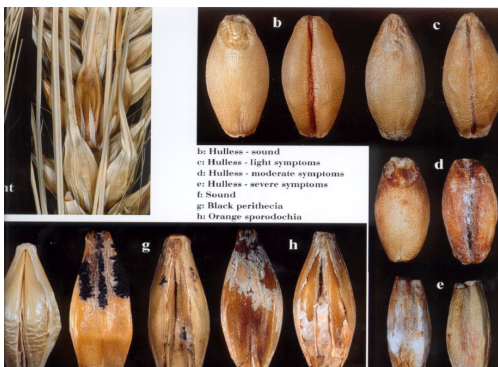


Courtesy J. Marshall

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31

FHB of Barley



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Courtesy Jianli Chen

32

Fusarium Head Blight

Not a new disease – 1st described in the U.S. in 1884

Epidemics have occurred in Canada, the Midwest, and mid-Atlantic states since 1917

Disease occurs wherever wheat and barley are grown – up to 50% yield loss

Toxin produced during grain infection

➔ feed refusal, human health concerns, gushing in production of beer

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33

Fusarium Head Blight

Why worry now?

Not a new problem

Common and severe in some irrigated wheat fields in 2013

- widespread but low intensity in southeastern WA dryland spring wheat

Increased reports and samples of FHB in the past few years

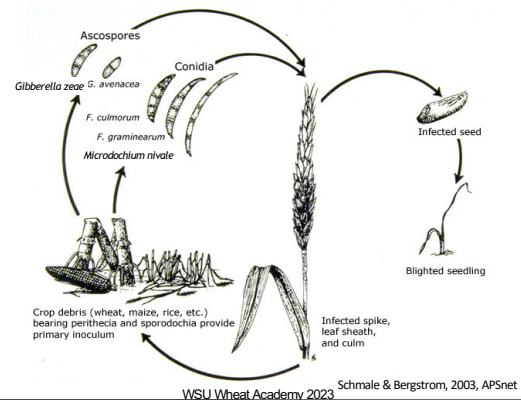
Concerns over vomitoxin-contaminated grain

➔ Produce tricothecene mycotoxins
= Deoxynivalenol (DON), aka vomitoxins

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34

Disease Cycle of FHB



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Schmale & Bergstrom, 2003, APSnet

35

Factors Affecting FHB

Temps 59-86°F w/ >90% RH before, during, & after flowering

- frequent rain showers or irrigation

Reduced tillage that retains residue on soil surface

Short rotations following previously infected crops, e.g. corn

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36

Controlling FHB

Crop rotation to allow infested residue to decompose – avoid following corn

Tillage to bury residue/enhance decomposition

Healthy, treated seed

Variety selection*

Irrigation management

Fungicides – foliar & seed treatment

Harvest – higher fan speed

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37

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38

FHB Fungicides - 2023

[illegible]

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39

Seed Treatment of *Fusarium*-infected seed

Untreated	Treated
	



Courtesy of G. Bergstrom

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40

Rhizoctonia root rot



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41

Pythium vs. Rhizoctonia

Pythium

- Cool, wet
 - Fall through Spring
- Seedling stage
- Winter green-up
- Clay soils
 - Take longer to warm up
- Low spots
- Poor growth, thin
- Yellowing (N deficient-like)

Rhizoctonia

- Cool, wet
 - Fall through Spring
- Seedling stage
- Winter green-up
- Clay soils
 - Take longer to warm up
- Often circular, patchy, uneven height
- Green Bridge
- Poor growth, missing
- Yellowing (N deficient & drought-like)

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Pythium vs. Rhizoctonia



Pythium



Rhizoctonia

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Snow Mold Diseases



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Snow Mold Diseases



Speckled snow mold
(*Typhula ishikariensis*)



Pink snow mold
(*Microdochium nivale*)

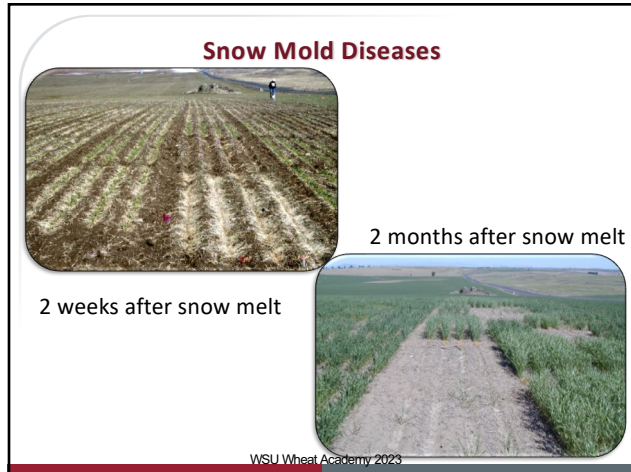


Gray snow mold
(*Typhula incarnata*)



Pythium snow mold
(*Pythium spp.*)

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46

Snow Molds

Pink Snow Mold

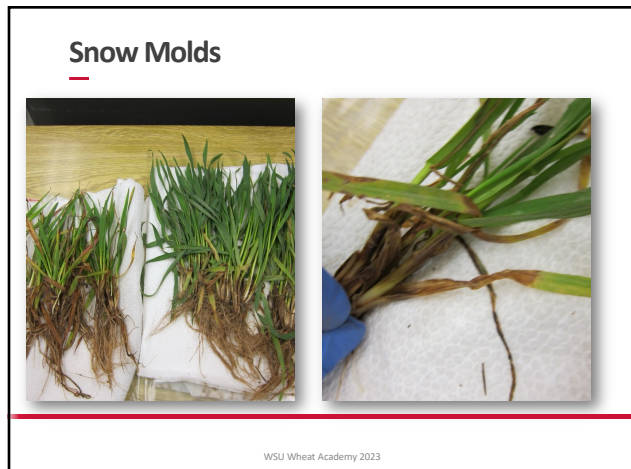
- *Microdochium*
- All grasses affected
- Requires wet, cold conditions
 - Frost, rain, fog, etc.
- Wet, matted appearance
- Cottony mycelium
- Orange-red-pink coloring
- Patches of damaged plants

Typhula Snow Molds

- Speckled/Grey snow molds
- All grasses affected
- Require snow cover for extended time
- Wet, matted appearance
- Cottony mycelium
- Color is off yellow
- Patches of damaged plants
- Sclerotia embedded in tissue

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47



48



49

Resistance to Snow Molds

- **Boundary**
- **Bruehl**
- **Curiosity CL+**
- **Eltan**
- **Farnum**
- **Keldin**
- **Mela CL+**
- **ORCF 103**
- **Otto**
- **Sequoia**
- **UICF Brundage**
- **WB-Arrowhead**
- **Xerpha**

Soft white, **Hard red**, **Club**

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50

Wheat Viruses

Soilborne Wheat Mosaic

- SBWMV
- Soil microorganism
- Patchy in field
 - Wet, low areas
- MUST catch leaf symptoms in late winter/early spring
 - After breaking dormancy

Barley Yellow Dwarf

- BYDV
- Aphid vector
- Yellow flag leaf
 - Or red, or purple, or green, or brown, or orange
- Short internodes ('Dwarf')

Wheat Streak Mosaic

- WSMV
- Eriophyid Mite Vector
- Wide cereal host range
- Late-harvested crops and irrigated fields
- First observed on field edges
- Curling of lower leaves
 - Mites often observed

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51

Soilborne Wheat Mosaic - SBWM



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52

SBWM

Yellow patches in fields

Mild green- to yellow-colored mosaic

- streaks of different colored tissue running in the same direction as leaf veins

Stunted plants

Rosetting

- stunted with short tillers

Affected plants tend to occur in areas where water runs

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53

SBWM

Disease of fall-sown wheat

Transmitted by soilborne fungus-like organism

→ *acts like other soilborne diseases in terms of distribution within fields and spread*

Infection occurs in the fall and symptoms appear in early spring

- symptoms fade and plants appear to recover as temperature increases in spring

Damage remains and yield is reduced

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54

SBWM Variety Trial, Umatilla, OR 2011

Irrigated circle on sandy soil with severe SBWM symptoms in 2010



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55

SBWM – Management

Disease resistance – only practical option



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56

SBWMV Resistant Varieties

- | | |
|-----------------|---------------|
| • ARS Pritchett | • Puma |
| • Genesis | • SY Dayton |
| • Ladd | • SY Ovation |
| • LCS Shark | • WB4303 |
| • ORCF-103 | • WB Junction |
| • ORCF-101 | • Whetstone |

Soft white, Hard red, Club

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57

Wheat Streak Mosaic



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58

Wheat Streak Mosaic



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59

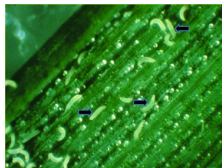
WSMV

Yellow, stunted plants in fields
Mild green- to yellow-colored mosaic

- streaks of different colored tissue running in the same direction as leaf veins

Rolling and trapping of leaves

Transmitted by the Wheat curl mite



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60

WSM Management

Green bridge management

Delayed seeding of winter wheat

Resistant varieties

- virus, mite or both
- *Wsm 1*, *Wsm 2* provide temperature-sensitive resistance
- nearly all PNW-adapted varieties are susceptible

61

Leaf Spotters

Physiological Leaf Spot

- Varietal responses
- Often low chloride/zinc
- Leaching conditions
- MOST COMMON!

Septoria Blotch

- Wet, cool weather
- Lower leaves
- Streaks brown and yellow
- Fruiting bodies in necrotic tissue
- Two consecutive rain days increases likelihood

Tan Spot

- Oval-shaped spots
- Brown surrounded by yellow
- **No** fruiting body on leaves (old straw in spring has fruiting bodies)
- Are you **SURE** it isn't physiological leaf spot?

Stagnospora Blotch

- Early Spring
- Lower leaves
- Irregular ovals or flecks with yellow halo
- *Tiny* fruiting bodies
- Can discolor spikelets too
- Looks like bacterial infection too

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62

Leaf Spotters



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63

Leaf Spotters



Credit: Texas A&M Soil and Crop Sciences

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64

Management Considerations

Disease	Cultural practices	Variety selection	Chemical control
Stripe rust	+	+	+
Eyespot	+	+	+
Ceph. stripe	+	+	-
Rhizoctonia root rot	+	-	-
Fusarium crown rot	+	-	-
FHB	+	+/-	+
Pythium root rot	+	-	+
Snow molds	+	+	-
Soilborne wheat mosaic	-	+	-
Wheat streak mosaic	+	-	-

65

Cultural Management Practices

Disease	Seeding date	Residue mgt	Green bridge	Fertility	Crop rotation	Soil pH
Stripe rust	+	-	+	+	-	-
Eyespot	+	+/-	-	-	-	-
Ceph. stripe	+	+/-	-	-	+	+
Rhizoctonia	+/-	+	+	-	-	-
Fusarium	+	-	-	+	-	-
FHB	-	+	-	-	+	-
Pythium	+	+	+	-	-	-
Snow molds	+	-	-	-	-	-
SBWM	+	-	-	-	-	-
WSM	+	-	+	-	-	-

66

Disease Information Resources

Wheat and Small Grains website

<http://smallgrains.wsu.edu/>

Twitter @WSUWheatDoc

Stripe rust alerts:

- updates by Dr. Chen begin in January

<http://striperust.wsu.edu/>

Variety Ratings: Stripe rust, eyespot,

Cephalosporium stripe

- WSCIA seed guides
- Variety Selection Tool

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67

Plant Disease Diagnostic Lab

- Whole plants whenever possible
- Range of symptoms
- Include a healthy plant
- As many photos as needed
- Carefully packaged
- Kept cool until delivery (via mail or in person)
- Delay = decay
- Fill-out submission form completely



WSU - Pullman Plant Pest Disease Clinic:

plant.clinic@wsu.edu

(509) 335-3292

Website: <https://plantpath.wsu.edu/diagnostic-clinic/>

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68

Questions?

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69