STRIPE RUST OF WHEAT

William Stump, University of Wyoming Extension Plant Pathologist
Carrie Eberle, University of Wyoming Extension Cropping Specialist
Wendy Cecil, University of Wyoming Plant Sciences Research Associate

In Wyoming and the Great Plains, there are three main rust fungal diseases that affect wheat; stem rust, leaf rust and stripe rust. Stem rust was responsible for severe epidemics in North America in the early 1900s causing substantial yield losses. With the introduction of resistant wheat varieties and eradication campaigns of the alternate host barberry, we rarely find stem rust in Wyoming, based on Cooperative Agricultural Pest surveys conducted in the last six years. Leaf rust is common in the Great Plains but has not been a problem in Wyoming in recent history. Conversely, stripe rust has become one of the most important disease pests of winter wheat in the region since the early 2000s.

Historically, stripe rust was a disease of cool, wet conditions, limited to the Pacific Northwest and occasionally found in the Great Plains. However, after 2000, stripe rust became widespread and problematic in the Great Plains despite warm temperatures that was thought to be restrictive to its growth. Scientists believe that new races of stripe rust have been introduced to U.S. wheat production areas. In addition to development

Figure 1. Symptoms of stripe rust on wheat with distinctive yellow-orange rust pustules on leaf. Symptoms may vary among varieties. Varieties with some resistance often have more tan coloration to the lesion. (Photo: Carrie Eberle)

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under warmer temperatures, these new races developed rapidly, producing new spores quicker and causing rapid disease development.

Stripe rust, also known as yellow rust, is caused by the fungus *Puccinia striiformis* f. sp. *tritici*. Hosts include most wheat types, rye, some weedy and improved pasture grass species and a few barley varieties (there is another variant that is specific to barley). Symptoms are characterized by obvious yellow-orange pustules arranged in narrow stripes on leaves, sheaths, awns and glumes. These pustules produce thousands of asexual yellow-orange spores (urediniospores), which theoretically can cause new infections that can produce new spores within 10 days. Under proper conditions and wind dispersal, this disease has the potential for rapid, large scale spread in a region. Symptoms on resistant varieties range from no symptoms to small necrotic spots to small isolated pustules with limited spore production. Although, stripe rust typically does not cause plant death, extensive infection can cause loss of photosynthetic capability, increased water use and shriveled, poor quality grain all resulting in significant yield losses.

LIFE CYCLE

The stripe rust fungus overwinters as mycelium (fungal growth) and/or urediniospores (asexual spores) produced on infected volunteer or fall planted wheat in regions with mild winters. For Wyoming disease outbreaks, this means spores from infected wheat from southern producing areas like Texas would be blown northward by the wind, with infection usually first detected in late April. Like many rust fungal pathogens an alternate host is required for the sexual stage. No alternate host for the stripe rust fungus has been identified but plant pathologists have recently demonstrated that barberry (*Berberis* sp.) can serve as the alternate host under laboratory conditions. It is still unclear if the sexual cycle plays a major role in stripe rust epidemiology.

Some surrounding states like Nebraska and Montana have discovered that stripe rust is overwintering certain years. Fungal growth on infected plants is reported to survive down to 23° F, meaning with snow cover and a mild winter, survival could be possible. If true, disease epidemics will occur sooner, compared to epidemics that depend on spores blowing up from southern, wheat

Figure 2. Stripe rust symptoms on susceptible (left) and resistant (right) varieties in the field. (Photo: Carrie Eberle)

producing states. Currently, the overwintering of stripe rust has not been established in Wyoming. In 2016, a southeast Wyoming fall wheat survey did demonstrate that fall infections were occurring, but found no evidence that these infections survived the winter on follow-up inspections. Optimal conditions for infection are leaf wetness for at least eight hours and temperatures in the 45-54° F range with a 32-70° F functional range of infection. Optimal disease development is under wet conditions and temperatures ranging from 50-59° F. Under these conditions, new infections can start producing new spores within 7-10 days resulting in rapid disease development. Toward the end of the season the rust fungus will produce noticeable black teliospores rather than the yellow urediniospores. These spores can survive the winter but are only infectious to the alternate host *Berberis* species and have little impact on stripe rust disease development. Severe outbreaks of stripe rust in our area are strongly associated with significant outbreaks in Texas and Oklahoma. Outbreaks in Texas typically occur in February and set the stage for outbreaks further north if environmental conditions are favorable.

MANAGEMENT

Loss estimates due to this disease are difficult to come by for Wyoming wheat production but up to 40% yield losses have been reported in Kansas. Planting varieties with resistance to stripe rust is the most effective and economical way to manage stripe rust. The latest information on the response of wheat varieties with regional correlation to Wyoming conditions can be found at http://bit.ly/Variety-Testing-Wheat. Included are three years of winter wheat varietal responses to stripe rust under Wyoming conditions (Table 1). These plots were not inoculated and relied on natural disease pressure which fluctuated by test site and year. Only incidence, the number of plants with at least one rust pustule, was measured, which is not the complete picture when assessing varietal response to a disease. Results should be used in conjunction with published varietal susceptibility to stripe rust prior to making variety selection decisions. Therefore, stripe rust disease reactions of most varieties grown in Wyoming are summarized from bordering state reports shown in Table 2.

Table 1. Wyoming tested winter wheat variety response to stripe rust disease 2016-2018. Data shown is for varieties present across all three years, for additional information see http://bit.ly/Wheat-Crop-Trials.

Variety	Incidence* (% plants with disease)		
	2016	2017	2018
Cowboy	75	83	80
Warhorse	33	10	0
SY Wolf	67	20	40
SY Monument	27	23	30
Hatcher	42	20	50
Sunshine	67	47	10

* Data averaged over Wyoming test sites.

Foliar fungicides can be used effectively for suppressing stripe rust. Fungicide timing is important to protect the upper leaves, especially the flag leaf, as these leaves contribute the most to grain development. Active monitoring of fields for first indications of stripe rust is important in protecting the wheat crop during this growth phase. Inspecting crops weekly when environmental conditions favor stripe rust development can pinpoint early disease outbreaks. Disease reports from Texas and Oklahoma can also be useful in predicting Wyoming disease outbreaks. There are high correlations with severe stripe rust outbreaks in these areas and development in our production region. Scouting reports can be found at the USDA wheat rust site: http://bit.ly/USDA-Cereal-Rust-Bulletins.

Fungicides in the Strobilurin class (Headline and Quadris) give excellent protection when used prior to infection. If infection has already started, it's recommended to use fungicides in the Triazole class (Tilt, Folicur, Alto and Prosaro) as products from this fungicide group are thought to offer stronger activity against recent infections. A premix product of the two classes can also be utilized (Quilt, Stratego, Twinline, Trivapro) that contain both classes of fungicides.

The economic benefits from fungicide applications in winter wheat has not been extensively investigated in Wyoming. In the absence of high disease pressure, it may not be economical to apply fungicides, especially in dryland wheat production. Three Wyoming studies

Table 2. The reaction of winter wheat varieties grown in Wyoming to stripe rust as measured in Colorado, Nebraska and Montana

Variety	Origin	Release Date	Market Class	Stripe Rust reaction**	Other Info.
Top planted varieties planted in Wyoming for 2016-2018					
Buckskin*	NE	1973	HRW	S	
Cowboy*	WY-CO	2011	HRW	S	
SY Wolf*	AgriPro	2010	HRW	MR-MS	
SY Monument*	Syngenta	2014	HRW	R	
Snowmass*	CO	2009	HWW	S-MS	
Warhorse*	MT	2013	HRW	R	Solid Stem
Judee*	MT	2011	HRW	R	Solid Stem
Willow Creek	MT	2005	Forage	R	
Other planted varieties planted in Wyoming for 2016-2018					
AP 503 CL2	AgriPro	2007	HRW	MS	
Antero*	CO	2012	HWW	R	
Armour	WestBred	2008	HRW	R	
Bearpaw*	MT	2011	HRW	S	Solid Stem
Brawl CL Plus*	CO	2011	HRW	S-MS	
Byrd*	CO	2011	HRW	S-MS	
Camelot	NE	2008	HRW	S-MS	
Centerfield	OK	2006	HRW	MS-MR	
Denali*	CO	2011	HRW	S	
Freeman*	NE	2013	HRW	MR	
Goodstreak*	NE	2002	HRW	MR	
Hatcher*	CO	2004	HRW	MR-MS	
Jagalene	AgriPro	2002	HRW	MR	
Jerry	ND	2001	HRW	S	
Langin*	CO	2016	HRW	MS-MR	
Pronghorn	NE	1996	HRW	R	
Settler CL*	NE	2008	HRW	S-MS	
Sunshine*	CO	2014	HWW	S-MS	
SY Sunrise*	Syngenta	2015	HRW	MR-R	
WB Cedar	WestBred	2010	HRW	MR-MS	
WB Grainfield*	WestBred	2013	HRW	MR	
Winterhawk*	WestBred	2007	HRW	MS	
Yellowstone	MT	2005	HRW	R	

*Indicates varieties in the Wyoming 2016-2018 winter wheat variety trials.

**R=Resistant, MR=Moderately Resistant, MS=Moderately Susceptible, S=Susceptible. Results were compiled using varietal stripe rust reactions from Nebraska, Colorado and Montana testing when available. Please note, disease response can be variable based on environmental conditions, stage of plant at infection and inoculum pressure.

Table 3. Management of Stripe Rust of Irrigated Winter Wheat effects on disease and yield in 2017 irrigated wheat grown in Lingle, Wyo. (W.L. Stump and W. Cecil., U of WY; 2017).

Treatment, rate (fl oz/A)[z]	Application timing[y]	Stripe rust disease (12 Jun)[x]		Grain yield (bu/A)
		Incidence (# plants/10)	Severity (% of leaf tissue affected with stripe rust)	
1. Non-treated		10.00 a	18.5 a	69.8 c
2. Alto 100 0.83SL, (4.0)	A	8.25 ab	5.0 b	86.1 ab
3. Tilt 3.6EC, (2.0)	A	9.25 a	5.5 b	79.8 bc
4. Trivapro 2.21SE, (9.4)	A	6.75 b	5.0 b	80.0 abc
5. Priaxor 4.17SC, (9.0)	B	1.00 c	0.0 c	90.9 a
6. TwinLine 1.75EC, (9.0)	B	0.50 c	0.0 c	86.1 ab
7. Alto 100 0.83SL, (9.4)	A	0.25 c	0.0 c	86.1 ab
Trivapro 2.21SE, (13.7)	B			
8. Trivapro 2.21SE, (9.4)	A	0.50 c	0.0 c	87.7 ab
Trivapro 2.21SE, (13.7)	B			

[z] All fungicide treatments included the surfactant Induce at 0.25% v/v.

[y] Fungicide applications dates: A= 1 May, B= 26 May.

[x] Treatment means followed by different letters differ significantly (Fisher's protected LSD, $p \leq 0.05$).

on irrigated winter wheat and stripe rust disease management in 2010, 2011 and 2017 showed significant disease pressure only in 2017, which result in a yield increase with fungicide application. Results from this trial (Table 3) also support the importance of application timings to protect the upper leaves. This study evaluated two fungicide application timings and multiple fungicides. The fungicide Alto is in the Triazole class and Trivapro is a premix product (premix of three fungicide groups). Two timings were explored, an earlier than normal application that potentially corresponds with a last herbicide application at wheat tillering and a traditional timing at flag leaf emergence. There were also two treatments utilizing both timings. These were compared to some commonly used fungicides: Tilt (triazole), Priaxor (premix) and Twinline (premix) fungicides. Applications made at tillering reduced disease severity on average 43-72% and was not as effective as fungicides applied at the flag leaf stage, which had 97-99% suppression. Having treatment applications at both tillering and at flag leaf did not improve disease suppression compared to the flag leaf applications only. Most fungicide treatments resulted in greater plot yield than the non-treated. Despite improved disease suppression with treatments made at the later application timing, yield was statistically similar among most of the fungicide treatments.

CONCLUSIONS

It is expected that stripe rust will continue to be a disease threat for Wyoming wheat producers. Currently, Wyoming farmers can manage disease outbreaks by selecting varieties with reduced susceptibility (Table 2) and monitoring fields for outbreaks to make decisions related to the need of fungicide application.

Figure 3. Symptoms of stripe rust on wheat. (Photo: Carrie Eberle)

RESOURCES

https://www.nass.usda.gov/Statistics_by_State/Wyoming/Publications/Special_Interest_Reports/

http://www.uwyo.edu/uwexpstn/research-results-impacts/variety-trials/wheat.html

http://www.uwyo.edu/capsweb/pest-information-summaries-maps/plant-diseases/puccinia-striiformis.html

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