Identification and Management of Stem Rust on Wheat and Barley

Stem rust, leaf rust, and stripe rust comprise a complex of diseases that reduces wheat and barley grain production. These rust diseases occur in nearly all areas of the United States and Canada. The importance of any member of the complex at a given location is determined by specific interactions with current wheat varieties, crop growth stage, and weather conditions.

Stem rust has been present in North America for hundreds of years. A series of particularly severe outbreaks occurred during the early 1930s and 1950s. These outbreaks caused serious yield loss in many parts of the United States and Canada with the greatest losses in the Great Plains. More localized outbreaks of wheat stem rust occurred in the southern Great Plains as recently as 1986. Stem rust became a problem in barley in the late 1980s and early 1990s. In all these cases, the increase in frequency and intensity of the disease was associated with changes in the population of the stem rust fungus, which enabled it to overcome genetic resistance of common varieties.

After several decades of control with genetic resistance, new genetic variants (races) of the stem rust fungus have emerged as a threat to wheat production. The first of these races, known as 'Ug99', was originally detected in Uganda, Kenya, and Ethiopia. Since this initial detection, additional races of the fungus have been reported and are further complicating efforts to contain the problem.

If these new races spread to North America, they may threaten wheat and barley production. In preparation for the possible introduction of these new races of stem rust, a number of critical questions arise regarding the most effective ways to identify, monitor, and manage the disease. This publication answers these critical questions with the best available information about the emerging threat.

Why does the genetic resistance appear to fail?

Currently genetic resistance is an effective means of managing the rust diseases of wheat and barley. Because the populations of the fungi that cause rust diseases can change and adapt to the resistance genes of current varieties, the durability of this genetic resistance has been problematic. These changes occur when naturally occurring genetic changes allow members of the fungal population to overcome the genetic resistance of the plant. The rust fungi have a tremendous reproduction potential and are easily moved by wind; therefore, a new race of stem rust often increases rapidly, resulting in outbreaks of disease throughout a large geographical region.

What is the regional risk of stem rust epidemics?

If stem rust reemerges as a serious problem in North America, historical accounts of stem rust outbreaks will provide important information about where the disease is likely to be most severe and cause the largest reductions in yield. Stem rust normally survives the winter months in the southern United States and Mexico. The disease then becomes established near overwintering locations in southern states and is subsequently moved north by weather systems. Potential yield

loss in northern states is strongly influenced by the intensity of the disease outbreaks in southern states and the timing of these northerly movements of the disease, relative to crop development.

Based on the historical accounts of stem rust outbreaks, it appears that in most years the disease may develop too late to cause much yield loss in Texas and Oklahoma. Moderate yield losses could occur in Kansas and Nebraska, but the greatest losses are most likely to occur in South Dakota, North Dakota, Minnesota, Manitoba, and Saskatchewan (**Figure 1**). Historical reports of stem rust outbreaks indicate a lower risk of yield loss east of the Mississippi River and in the Pacific Northwest.

Although this historical information provides some useful insights into where stem rust is most likely to be a problem, recent changes in agricultural production may influence the current risk of disease (**Table 1**). In most cases, current agricultural practices will diminish the risk of severe stem rust relative to historical outbreaks of disease.

How will current wheat and barley varieties respond to the new types of stem rust?

The introduction of one or more new races of stem rust into North America might cause dramatic changes in the stem rust reaction of many wheat varieties. The magnitude of this change in disease resistance depends on the diversity of the new population of stem rust, specific combinations of resistance genes present within each variety, and interactions with the environment.

Until the exact reactions to the new races of stem rust can be determined, it may be useful to group varieties based on the stem rust resistance genes they contain. If stem rust overcomes an important resistance gene, all varieties protected by that gene will likely experience significant reductions in stem rust resistance. Varieties within other groups, which have other resistance genes, may remain unaffected.

Scientists around the world are working to incorporate new sources of resistance that will reduce the risk of regional disease outbreaks. Until these sources of resistance become widely available, farmers should evaluate their regional risk of disease and carefully evaluate the sources of genetic resistance used on their farm. Planting varieties with different sources of resistance may help reduce the potential that any single race of stem rust will affect all varieties on a farm. Information regarding genetic resistance of many common wheat and barley varieties can be found on the USDA's Cereal Disease Laboratory website: *www.ars.usda.gov/mwa/cdl*.

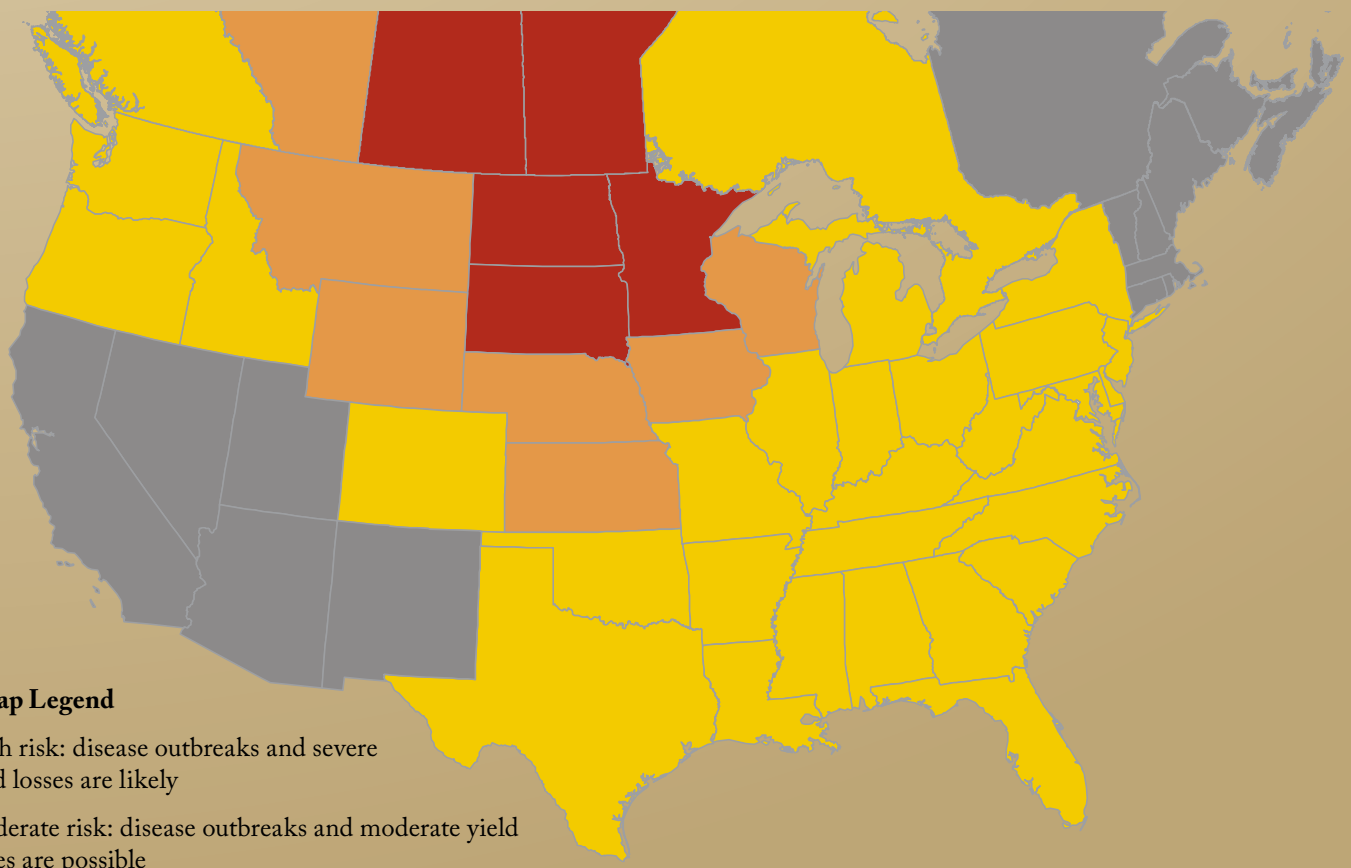
Understanding the terminology of rust resistance genes affected by 'Ug99'

The populations of stem rust causing problems in other parts of the world can be grouped by the resistance genes that they are able to overcome. These stem rust resistance genes are generally designated by an abbreviation for stem rust (*Sr*) and a unique code of letters and numbers that help scientists communicate more effectively when breeding new varieties for disease resistance. The original 'Ug99' is able to overcome the stem rust resistance gene *Sr31*. Since this initial discovery, additional types of the fungus have been discovered that are able to overcome the resistance genes *Sr24*, and *Sr36*. These resistance genes are the basis for the genetic vulnerability that has scientists around the world concerned about potential outbreaks of stem rust.

Table 1. *Factors influencing the risk of stem rust and severe yield losses relative to historical outbreaks of the disease.*

Change to the production system	Potential affect on stem rust outbreaks
In many areas, less land is used for wheat and barley production. These areas of cultivation are more isolated from each other.	The distance between fields may cause the disease to spread more slowly and reduce the risk of movement between regions. Areas away from main areas of production may escape severe disease.
Wheat and barley production have moved to areas with historically drier climates.	Growing wheat and barley in these drier climates may reduce the risk of disease development.
Many wheat varieties mature earlier, relative to those that were grown a few decades ago.	Yield losses to stem rust are greatest when severe disease develops during the early stages of grain development. Varieties that mature earlier may escape serious yield losses.
Access to highly effective fungicides and application technologies	It may be possible to reduce the influence of the disease on yield and slow regional spread of stem rust with fungicides.

Figure 1. *Estimated risk of yield losses caused by stem rust in North America based on historical records of disease outbreaks.*

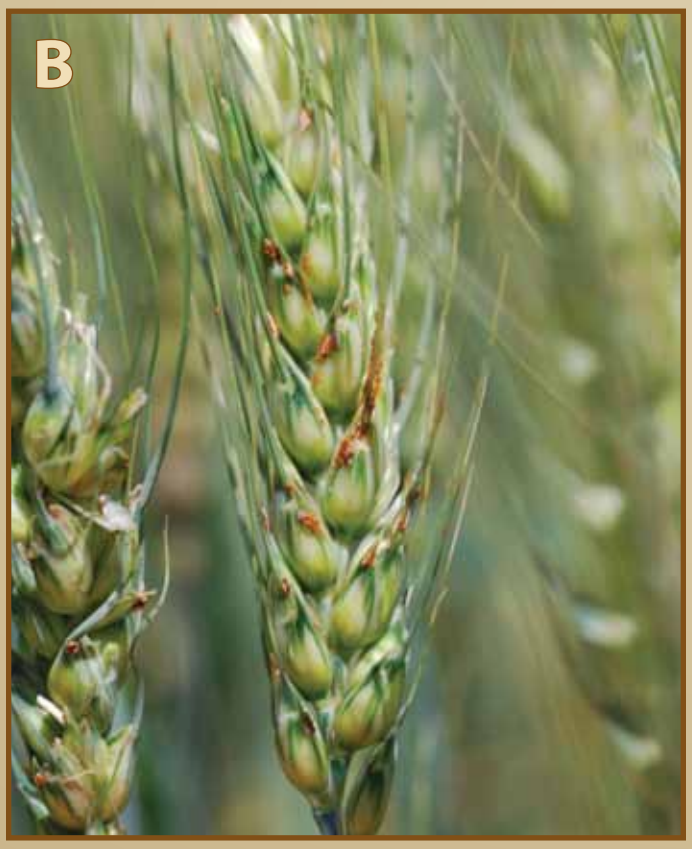


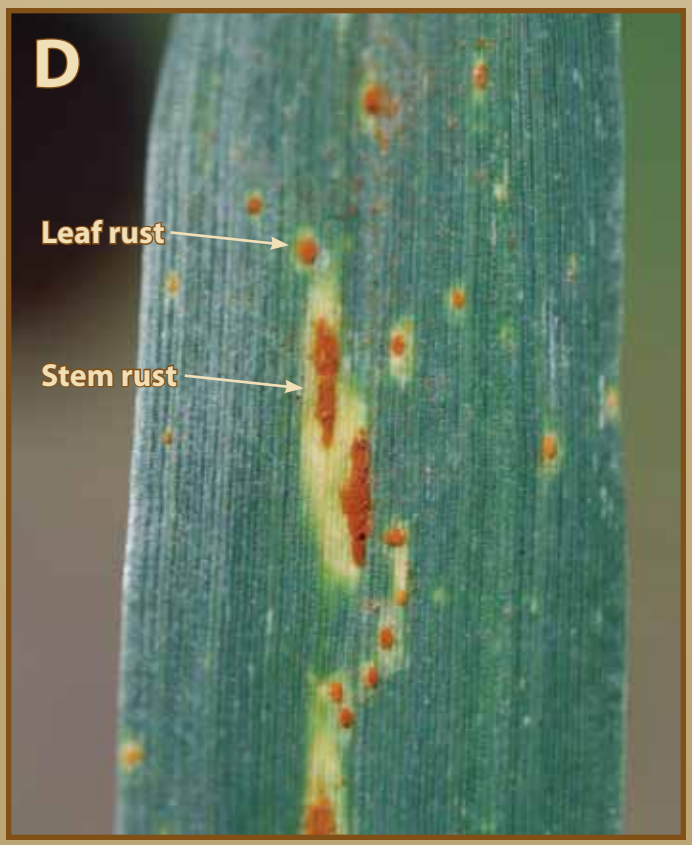
Risk Map Legend

- High risk: disease outbreaks and severe yield losses are likely
- Moderate risk: disease outbreaks and moderate yield losses are possible
- Low risk: disease outbreaks causing moderate yield losses are rare
- No historical information

Based on information summarized by Leonard, K. J. 2001. In P.D. Peterson (ed) Stem rust of wheat: from ancient enemy to modern foe. APS Press, St. Paul, MN.

Figure 2. *Key diagnostic features of stem rust.*





A. Stem rust commonly infects stems, leaves, and leaf sheaths.

B. Stem rust occasionally infects parts of the head including glumes and awns.

C. Stem rust causes oval-shaped or elongated blister-like lesions. Tearing or ripping of the outer layers of the plant tissue is visible without magnification.

D. Stem rust lesions tend to be larger and longer than those caused by leaf rust.

How is stem rust identified?

Using several key diagnostic features, stem rust can be distinguished from other rust diseases of wheat. When severe, stem rust can be differentiated from leaf rust or stripe rust by the parts of the plant that are infected. Stem rust is able to infect the stems, leaves, and leaf sheaths of the plant (**Figure 2**). This infection of the stem helps separate it from the other rust diseases. Leaf rust can infect the leaf sheath that wraps around the stem, but not the stem itself.

When the disease is less severe and only a few lesions can be found, it is important to focus on specific characteristics of the lesions. Stem rust causes elongated or oval-shaped blister-like lesions. The orange-red spores of the fungus burst through outer layers of the plant tissue giving the margins of the lesion a tattered appearance. This tearing of the plant tissue is visible without magnification. Compared to stem rust, the lesions of leaf rust are smaller, tend to be more round, and cause less tearing of the outer plant tissue.

Early detection of 'Ug99'

Early diagnosis of the new races of stem rust might provide time for farmers to respond to any emerging disease threats. This diagnosis may allow growers to respond with fungicides where appropriate and aid in variety selection in subsequent years. Most common wheat and barley varieties are resistant to the current North American population of stem rust. Therefore, any detection of stem rust should be brought to the attention of disease specialists. The disease specialist will make a preliminary evaluation of the sample and send suspect samples to the experts at the USDA's Cereal Disease Laboratory in St. Paul, Minnesota or AAFC Cereal Disease Research Center in Winnipeg, Manitoba to confirm the diagnosis. Disease specialists in your state or province can be found through your local extension office or by contacting a diagnostic laboratory near you. Contact information is provided at the end of this publication.

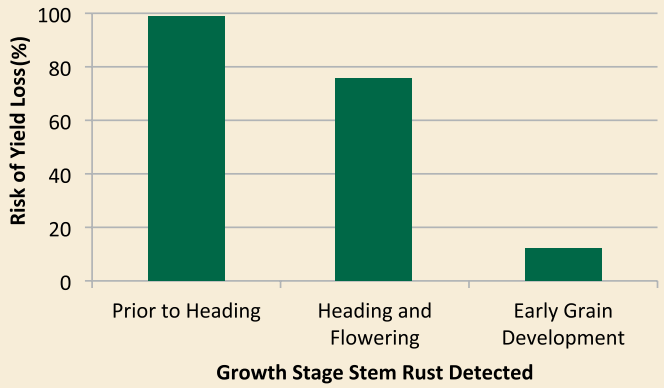
How much yield loss can stem rust cause?

Stem rust is generally considered the most damaging of the cereal rust diseases because it can infect leaves, stems, and heads of the developing plants. Plants severely damaged by stem rust are often predisposed to lodging, which complicates grain harvest and further increases yield losses.

The greatest yield losses are likely to occur when plants become infected with stem rust early in their growth and development (**Figure 3**). Even low levels of the disease before heading can result in severe disease during the early stages of grain development and serious yield loss.

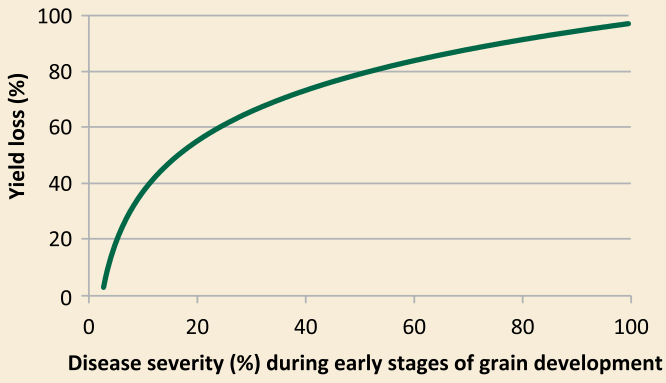
The risk of significant yield loss is reduced when the disease occurs during the later stages of grain development or when varieties with moderate levels of genetic resistance slow the development of disease. Estimates of potential yield loss can be obtained by evaluating the severity of stem rust during the early stages of grain development (**Figures 4** and **5**).

Figure 3. *Potential yield losses caused by stem rust on wheat are influenced by disease severity and timing of disease onset relative to crop growth and development.*



Based on research published by Calpouzos et al. 1976. Minn. Agric. Exp. Stn. Tech. Bull. 307:1-23.

Figure 4. *Estimated yield loss resulting from different levels of stem rust severity at the ¾ berry stage (Feekes growth stage 10.54).*



Based on research published by Romig and Calpouzos 1970. Phytopathology 60:1801-1805.

Can stem rust be effectively managed with foliar fungicides?

If stem rust reemerges as a problem in North America before new varieties with effective resistance become available, it should be possible to manage the disease and reduce potential yield losses with foliar fungicides. Recent research suggests that many of the widely marketed fungicides provide very good to excellent control of stem rust (**Table 2**). In North America, these same products generally also provide control of leaf rust, stripe rust, Stagonospora leaf blotch, tan spot, and powdery mildew. Regions with a history of problems with Fusarium head blight, however, should avoid products containing strobilurin fungicides after head emergence. Research shows that the strobilurin fungicides provide little or no protection against Fusarium head blight and may aggravate the mycotoxin problems associated with that disease.

Application timing

It is important to protect the upper portions of the crop canopy from infection by stem rust and other diseases; these leaves provide most of the resources used by the plant to fill the developing grain. In general, fungicide applications made between flag leaf emergence and flowering provide the most effective disease control and best preserve yield potential of the crop. Most fungicide products provide 14 to 21 days of protection against disease. After this time, a gradual increase in disease severity can be expected. Normally, this late increase of disease does not result in serious yield loss (**Figure 3**).

Staying informed about the regional risk of disease and taking the time to scout for disease greatly increases the chance of effective fungicide use. The greatest risk of yield loss typically occurs when stem rust becomes established before heading. Disease specialists in North America distribute information about the regional risk of stem rust and other diseases electronically via e-mail and the website of the USDA's Cereal Disease Laboratory. Subscription information to these e-mail lists and online access to the disease observations can be found at *www.ars.usda.gov/mwa/cdl*.

Figure 5. *Variations in stem rust severity.*

Severity less than 4 percent.

Severity 8 to 12 percent.

Severity 80 percent or greater.

Table 2. *Efficacy of foliar fungicides available for management of stem rust*

Efficacy is based on proper application timing to achieve optimum performance of the fungicide as determined by labeled instructions and overall level of disease in the field at the time of application. Differences in efficacy among fungicide products were determined by direct comparison among products in field tests and are based on a single application of the labeled rate as listed in the table. This table includes the most widely marketed products and is not intended to be a list of all labeled products. For current efficacy information, see K-State Research and Extension publication *Foliar Fungicide Efficacy Ratings for Wheat Disease Management*, EP-130, available at *www.ksre.ksu.edu*.

Fungicide(s)					
Class	Active Ingredient	Product	Rate/a (fl. oz)	Stem Rust[1]	Harvest Restriction
Strobilurin	Azoxystrobin 22.9%	Quadris 2.08 SC	6.2 - 10.8	VG	45 days
	Pyraclostrobin 23.6%	Headline 2.09 EC	6.0 - 9.0	G	Feekes 10.5
Triazole	Metconazole 8.6%	Caramba 0.75 SL	10.0 - 17.0	E	30 days
	Propiconazole 41.8%	Tilt 3.6 EC PropiMax 3.6 EC Bumper 41.8 EC	4.0	VG	Feekes 10.5
	Prothioconazole 41%	Proline 480 SC	5.0 - 5.7	VG	30 days
	Tebuconazole 38.7%	Folicur 3.6 F[2]	4.0	E	30 days
	Prothioconazole 19% Tebuconazole 19%	Prosaro 421 SC	6.5 - 8.2	E	30 days
Mixed mode of action	Metconazole 7.4% Pyraclostrobin 12%	TwinLine 1.75 EC	7.0 - 9.0	VG	Feekes 10.5
	Propiconazole 11.7% Azoxystrobin 7.0%	Quilt 200 SC	14.0	VG	Feekes 10.5
	Propiconazole 11.7% Azoxystrobin 13.5%	Quilt Xcel 2.2 SE	14.0	--[3]	Feekes 10.5
	Propiconazole 11.4% Trifloxystrobin 11.4%	Stratego 250 EC	10.0	VG	35 days

[1] Efficacy categories: NR=Not Recommended; P=Poor; F=Fair; G=Good; VG=Very Good; E=Excellent.
[2] Multiple generic products containing tebuconazole may also be labeled in some states.
[3] Insufficient data to make statement about efficacy of this product

This information is provided only as a guide. It is the responsibility of the pesticide applicator by law to read and follow all current label directions. No endorsement is intended for products listed, nor is criticism meant for products not listed. Members or participants in the NCERA-184 committee assume no liability resulting from the use of these products.

Will specialized application equipment be needed for fungicide applications?

Good coverage of a crop canopy is critical for the success of a fungicide application. Nearly all the fungicide products currently marketed for wheat disease control are considered locally systemic. This means chemicals are readily absorbed by plant tissues but will not move to other parts of the plant at effective levels. Therefore, only plant tissues that receive the application will be protected from the disease.

Preliminary research evaluating the efficacy of stem rust control using fungicides suggests that good disease control can be achieved using standard application equipment. These small-plot experiments attempt to simulate ground applications of fungicides made at a rate of 15 to 20 gallons per acre using flat-fan nozzles with orifice size and pressure combination needed to produce a medium-fine droplet size. Experiments are currently underway to evaluate different sprayer configurations that could optimize coverage and disease control.

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For additional assistance identifying diseases of wheat or barley contact:

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