# Leaf, Stem, and Stripe Rust Diseases of Wheat

Guide A-415

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## Introduction

Rust diseases of wheat are among the oldest plant diseases known to humans. Early literature on wheat cultivation mentions these devastating diseases and their ability to destroy entire wheat crops. Since rust discovery, numerous studies have been conducted on the life cycles of rust pathogens and their management. The information gained from these studies has enabled us to develop best management practices that reduce the impact of the diseases. Today, worldwide epidemic losses are rare, though the diseases can occur at significant levels in particular fields or throughout a particular growing region. The persistence of rust as a significant disease in wheat can be attributed to specific characteristics of the rust fungi. These characteristics include a capacity to produce a large number of spores—which can be wind-disseminated over long distances and infect wheat under favorable environmental conditions—and the ability to change genetically, thereby producing new races with increased aggressiveness on resistant wheat cultivars.

## Symptoms

There are three rust diseases that occur on wheat: stem rust, leaf rust and stripe rust. These diseases are each caused by a particular species of the "rust" fungus, *Puccinia*. Rust fungi all produce similar disease symptoms on the host plants and have similar requirements for infection. The diseases get their name from their appearance on the plant (Figure 1). Infection can occur on any above-ground plant part, leading to the production of pustules that contain thousands of dry yellow-orange to reddish-brown or black spores. These pustules give the appearance of "rust" on the plant.

Stem rust occurs primarily on stems but can also be found on leaves, sheaths, glumes, awns, and even seed. Symptoms begin as oval to elongate lesions that are generally reddish-brown in color. In the late stages of the disease, erumpent pustules produce numerous black sooty spores. Severe infestations with many stem lesions may weaken plant stems and result in lodging.

Leaf rust is generally found on leaves but may also infect glumes and awns. Symptoms begin as small circular to oval yellow spots on infected tissue of the upper leaf surface. As the disease progresses, the spots develop into orange-colored pustules that may be surrounded by a yellow halo (Figure 1). The pustules produce a large number of spores that are easily dislodged from the pustule, resulting in an "orange dust" on the leaf surface or on clothes, hands, and equipment. As the disease progresses, black spores may be produced, resulting in a mixture of orange and black lesions on the same leaf. Tiny orange lesions may be present on seed heads, but these lesions do not develop into erumpent pustules. This difference helps to distinguish leaf rust from stem rust.

Stripe rust is distinguished by the presence of light yellow, straight-sided pustules that occur in stripes on leaves and heads. These elongate pustules are narrow and vary in length. As the pustules mature, yellow-orange spores are produced (Figure 1). As the disease progresses, tissues around the pustules turn brown and dry, resulting in a scorched appearance. The arrangement of pustules into stripes is an important distinguishing characteristic of this disease. Chlorosis, or yellowing, of leaves can be quite evident with both leaf and stripe rust, and fields with plants displaying severe symptoms may be easily detectable from a distance (Figures 2 and 3).

## Causal Organisms

Stem rust (also known as black stem rust) is caused by *Puccinia graminis* f. sp. *tritici*. It is primarily a disease on wheat, though it can also cause minor infections on certain cultivars of barley and rye. Leaf rust is caused by *Puccinia recondita* f. sp. *tritici* (now known as *Puccinia triticina*). Like the stem rust fungus, this pathogen is primarily a problem on wheat, but it may be weakly pathogenic on some cultivars of barley, triticale, and some species of goatgrass and wheatgrass. The third rust disease, stripe rust, is caused by *Puccinia striiformis.* This pathogen also affects barley, rye, triticale, and over 18

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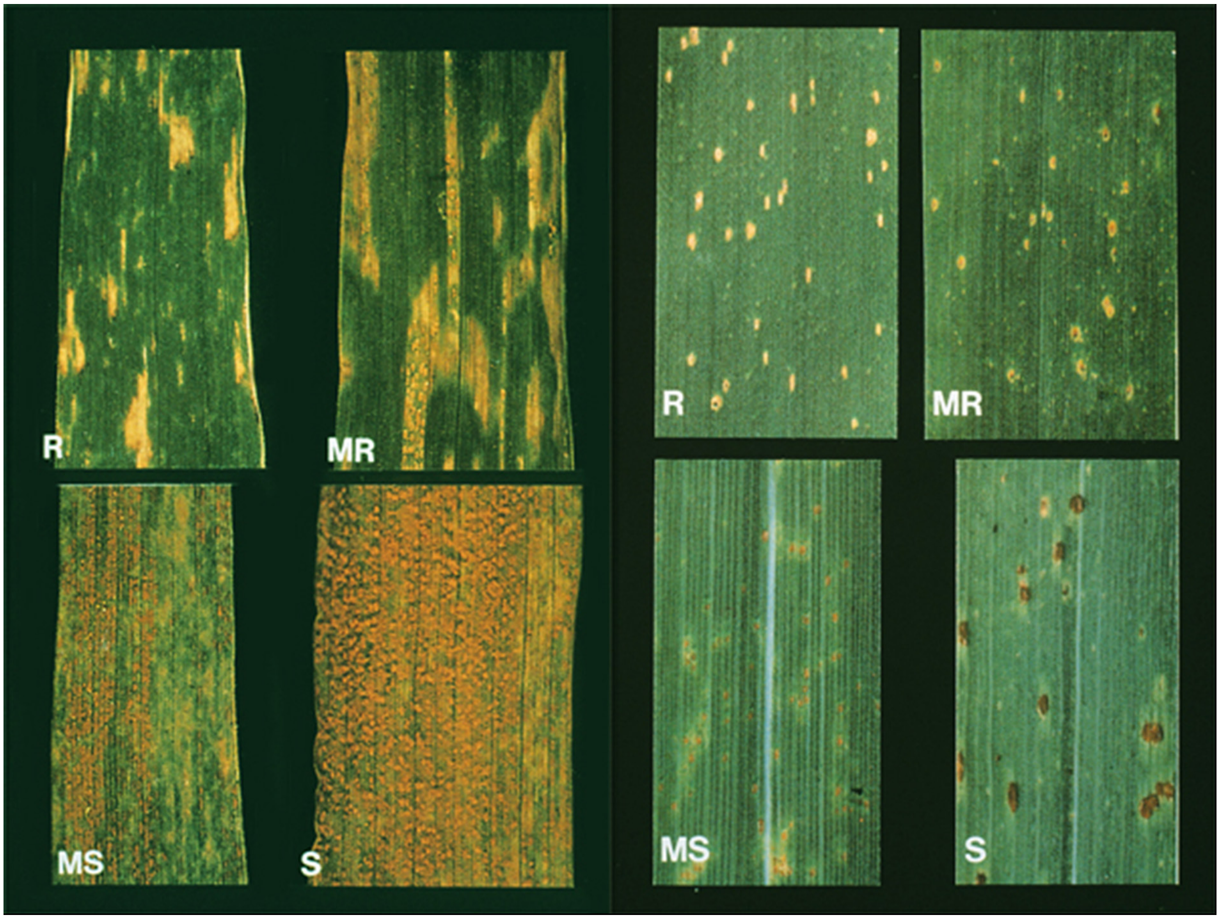


*Figure 1.* **Relative resistances of wheat to stripe (left) and leaf rust (right): R = resistant, MR = moderately resistant, MS = moderately susceptible, and S = susceptible. Source: Rust Scoring Guide, Research Institute for Plant Protection, Wageningen, Netherlands.**

*Figure 2.* **Chlorosis of leaves caused by leaf and stripe rust infection.**

*Figure 3.* **Variety of wheat susceptible to leaf and stripe rust, with noticeable severe leaf chlorosis, compared to tolerant varieties in adjacent plots with little or no leaf chlorosis.**

LIFE CYCLE OF *Puccinia triticina*

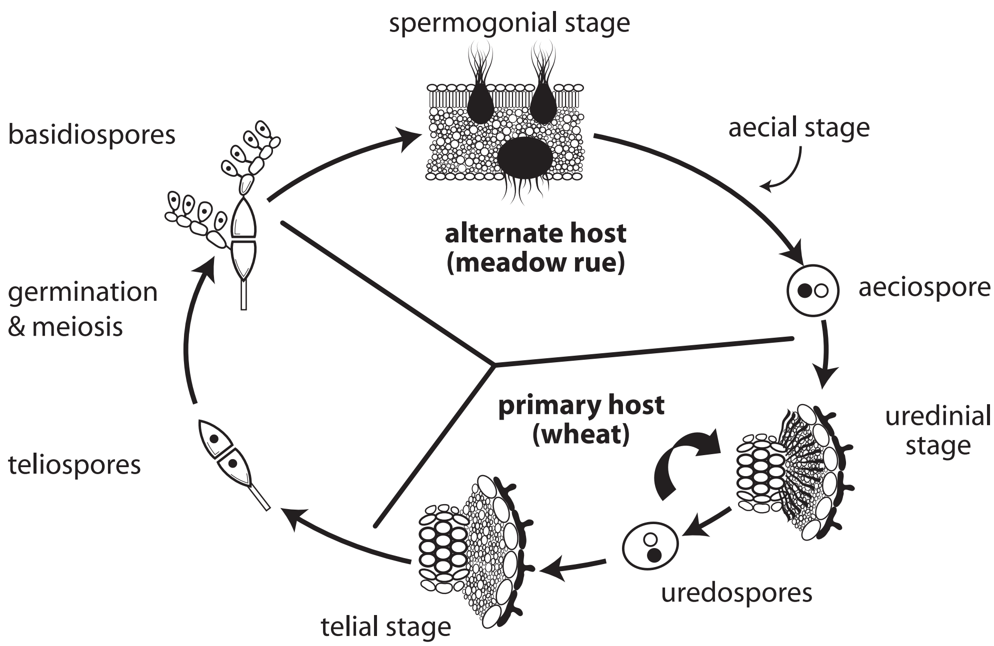


***Figure 4.*** **Leaf rust life cycle showing both primary and alternate hosts. Graphic by Jerry Downs. Adapted from C.J. Alexopoulus, C.W. Mims, and M. Blackwell. 1996. *Introductory Mycology,* 4th ed. John Wiley and Sons, Inc.**

species of grasses. Economic losses from stripe rust are generally restricted to wheat and barley crops.

These causal agents exist in many different physiologic races that vary in their aggressiveness and pathogenicity on various host plants. Plant breeders have been able to develop genetic resistance (or tolerance) within wheat cultivars to a variety of races of the rusts. The resistant cultivars have been highly effective such that many rust races prevalent in the past are now nearly nonexistent. However, sexual recombination and mutation in the pathogens allow for development of new races. Therefore, wheat breeders are constantly monitoring old cultivars for continued tolerance to the pathogen, as well as developing new cultivars with improved resistance to new and old races.

## Life Cycles

Rust fungi have complex life cycles, which may require two specifically different host plants and up to five different spore stages. Rust diseases that require two host plants to complete the life cycle generally have what is known as an economic host and an alternate host. The economic host, in these diseases, is wheat. The alternate host is typically a weed or native plant (Figure 4). For example, barberry (*Berberis vulgaris*) is the primary alternate host for the stem rust fungus. Infection of barberry results in circular, yellow- to red-colored pustules on the underside of the leaves. Spores (aeciospores) produced on barberry plants infect wheat, and another type of spore (basidiospores) produced on wheat infects barberry plants. Although both hosts are necessary to complete the full life cycle, epidemics on wheat can develop rapidly because spores (uredospores) produced on wheat can cause auto-infection (spores infect the same plants on which they were produced). This spore stage of the life cycle is known as the repeating stage and is responsible for the rapid development of disease outbreaks.

Several plants have been identified as alternate hosts for leaf rust, including meadow rue, rue anemone, and Clematis. Stripe rust is not known to have any alternate hosts. In this case, the rust fungus has a modified life cycle with only one required host.

## Disease Development

Water on the leaf surface from intermittent rains or heavy dews and temperatures conducive for germination and growth of the pathogen are required for disease development. Stem rust is a warm-temperature disease that develops optimally between 65 and 85°F; however, the disease can occur at temperatures between 59 and 104°F. Leaf rust develops optimally at temperatures between 59 and 71°F, and the disease will progress until temperatures are above 80°F. Stripe rust is a lower-temperature disease that is generally found at higher elevations and in cooler climates. The optimal temperature for the development of this disease is 50 to 59°F, with disease progression ceasing at temperatures above 70°F.

When conditions are optimal for disease development, infection is completed in 6–8 hours and uredospores capable of causing secondary spread of the disease are produced in 7–10 days. Uredospores are relatively limited in the length of time they remain viable compared to other spore stages produced by rust fungi. Yet they are extremely efficient in spreading disease because they are produced in large quantities and are easily spread by wind. In locations with mild winters, uredospores have been found to survive year-round. Therefore, alternate hosts and some spore stages are required to complete the pathogen's life cycle but are not needed for the initiation of new infections each year.

## Prevention

One of the only early prevention methods for avoiding rust diseases or minimizing their impact is to plant a variety with known resistance. Variety resistance is the most economical method of control. In some cases, avoiding rust is not possible because of constant changes in strains (races) of the pathogens. For example, varieties formerly rated as "resistant" have, in recent years, begun to show signs of susceptibility at various locations. In many situations, the varieties remained resistant for only three to four years before showing signs of susceptibility. Large differences in susceptibility exist among wheat varieties. Contact your local county Extension office (http://aces.nmsu.edu/county/) for a list of adapted and potentially resistant wheat varieties for your area.

Destroying previous wheat plants and volunteer wheat, by tillage or herbicide, is another important step in the prevention of several diseases, including wheat streak mosaic, High Plains virus, barley yellow dwarf, and leaf and stem rusts. Eliminating the "green bridge" between wheat crops will help prevent mechanisms of carryover from one growing season to the next. Crop rotation is also very helpful at reducing disease carryover because many diseases are host-specific and proliferate when the same crop is planted year after year. Most disease cycles can be disrupted by as little as one year of rotation or fallow conditions. Several locations on the Southern High Plains have been "re-infected" from one year to the next by spores moving into the region from distant, more southerly areas where summer survival of rust is more likely. Therefore, even growers who take precautions to eliminate green bridge plants may experience infected fields due to the prolific spreading characteristic of the spores through wind.

**Table 1. Approximate Yield Loss in Relation to Severity of Rust on the Flag Leaf at Various Stages of Growth**

| Growth Stage | Severity of Leaf Rust on Flag Leaf (%) | | | | |
|---|---|---|---|---|---|
| | 10 | 25 | 40 | 65 | 100 |
| | Yield Loss (%) | | | | |
| Flowering | 10 | 15 | 20 | 30 | 35 |
| Milk | 2 | 5 | 8 | 14 | 20 |
| Soft Dough | 1 | 3 | 4 | 7 | 10 |
| Hard Dough | 1 | 1 | 1 | 3 | 5 |

Adapted from: B. Hunger and J. Edwards. *Foliar Fungicides and Wheat Production in Oklahoma*. Oklahoma State University Cooperative Extension Service.

## Managing Rust

In some cases, rust fungi may infect wheat after planting in fall; pustules and yellow (chlorotic) leaves can become evident early in the growing cycle of the plant. Usually, damage is minimal during tillering due to the onset of colder temperatures that are likely to eliminate the rust or reduce reproduction and spread of rusts over winter, especially in more northern parts of the state. However, if winter temperatures are mild, rust infection may persist into spring, and later growth stages could be affected. Field scouting is very important for monitoring of diseases and for diagnosis of problems before they get out of hand.

Infection into the spring and at growth stages of Feekes stage 8 (last leaf just visible; Figure 5) and higher should be the most concerning to producers growing wheat for grain harvest. The general consensus is that most of the grain yield losses attributed to leaf and stripe rusts are due to infection of the flag leaf, which is thought to be responsible for greater than 70% of grain filling. If the flag leaf is heavily infected prior to flowering, significant yield losses can be expected (Table 1). Highly susceptible varieties may have as much as 75% yield reduction if the flag leaf is heavily infected early on. Growers should be very cognizant of the spread of infection from lower leaves to higher leaves prior to last leaf emergence. If infection nears or occurs on the flag leaf, then fungicide treatment may be warranted, especially if warm, wet weather is forecasted. Not all situations will call for fungicide application, and the following conditions will increase the likelihood of profitable returns from spraying:

- Expected yields greater than 40 bu/acre. This eliminates dryland crops in NM in most years.

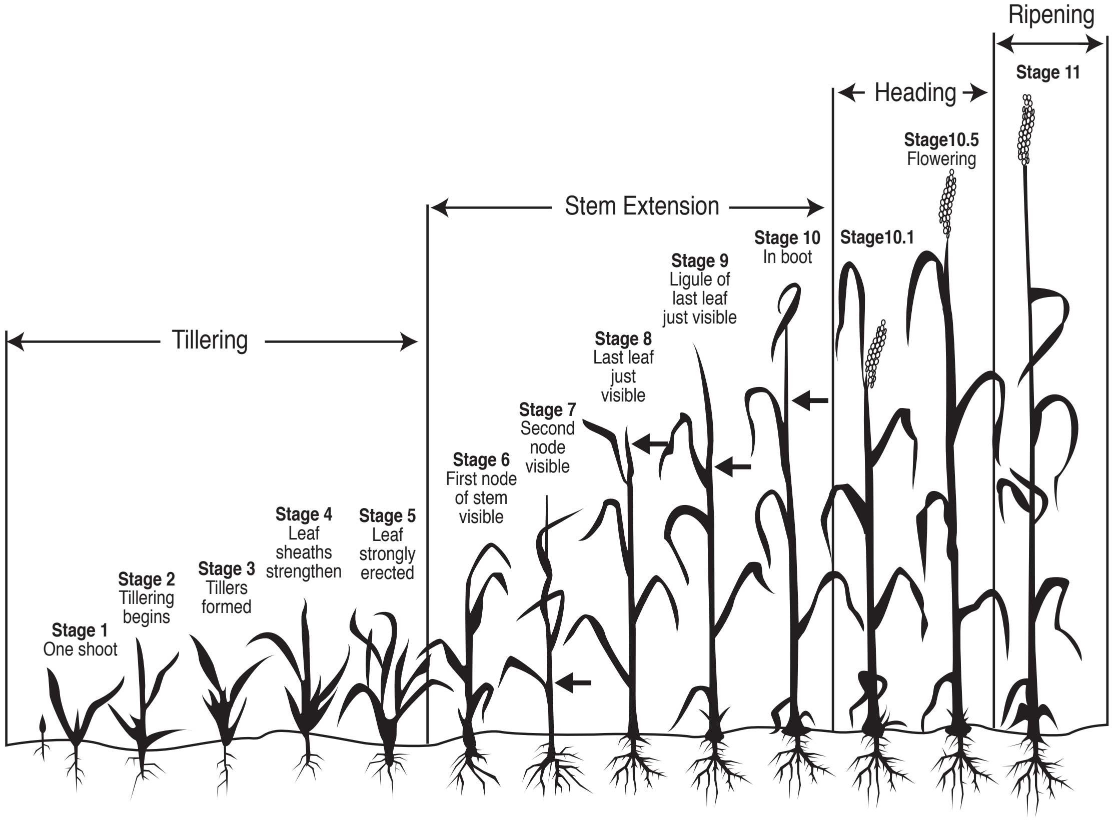


**Figure 5. Feekes scale of wheat development. Graphic by Jerry Downs. Adapted from E.C. Large. 1954. Growth stages of cereals. Illustration of the Feekes scale. *Plant Pathology*, 3, 128–129.**

- High market prices for wheat grain: at least $3.00/bu.
- Highly susceptible varieties.
- Late-maturing varieties.
- Dense crop canopy
- Anticipated wet weather and optimal temperatures discussed previously.

Foliar fungicides are expensive; therefore, great care should be taken in considering an application. In general, a minimum of 40 bu/acre expected yield and a market price of at least $3.00/bu are necessary in order to justify the use of a fungicide; however, this minimum yield will increase or decrease, depending on wheat grain price. Dryland wheat yields in New Mexico are normally too low to justify a fungicide application, except during times of high grain prices and if a low-cost fungicide is available. Ultimately, the grower must determine if the return on investment, especially if just a few dollars per acre, is enough to justify a fungicide application. Crop insurance programs and coverage must be considered as well. If it is determined that spraying is warranted, there are several types of fungicides available. The two main types of active ingredients are triazoles (e.g., Tilt, Folicur, Proline, and Propimax) and strobilurins (e.g., Quadris and Headline); some products include both of these fungicides (e.g., Stratego and Quilt). Costs will vary depending on product, dealer, time of purchase, and applicator costs; approximate costs can range widely, from $10 to $25/acre. Several studies have indicated that few differences exist among the various fungicides with regard to effectiveness of disease control; product selection should perhaps therefore be based on price. All of these fungicides exhibit good control of both leaf and stripe rust. Several fungicides can be applied through sprinkler irrigation systems, which may help keep application costs down in irrigated wheat. This discussion of fungicides is based on products registered at the time of publication. Constant changes in pesticide labeling at the federal and state level make it nearly impossible to publish a list of registered products that will last the lifetime of this publication. Although every attempt has been made to validate the information provided, it is the legal responsibility of producers, crop consultants, and applicators to read the entire product label to check for registered use, rates, and restrictions.

Spraying fungicides too early or late will result in inadequate disease control, loss of profits, and wasted time

| Table 2. Example of Net Return Calculation for Fungicide Application (irrigated and dryland scenario) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Irrigated/Low Grain Price** | | | | | | | | |
| 10%† | | 65 bu/acre | | $3.50‡ | | $13.50§ | | $9.25 |
| Expected Protection | × | Expected Yield Goal | × | Expected Grain Selling Price | - | Fungicide Application Cost | = | Predicted Net Return per Acre |
| **Dryland/High Grain Price** | | | | | | | | |
| 10%† | | 30 bu/acre | | $7.00‡ | | $13.50§ | | $7.50 |
| Expected Protection | × | Expected Yield Goal | × | Expected Grain Selling Price | - | Fungicide Application Cost | = | Predicted Net Return per Acre |

†An average 10% yield protection is considered.
‡Price will vary frequently and may be considerably higher if selling as certified seed.
§Total cost will vary depending on product and rates used, and applicator costs.

and money. The most effective time to apply fungicides is between last leaf emergence and complete head emergence. Applying fungicide after flowering oftentimes is not economically feasible because considerable damage has likely occurred to the flag leaf by this point. Protecting the flag leaf is of utmost importance. Fungicides are preventative and will not bring back healthy tissue once infection has occurred. Applications after milk and into soft dough stages are too late and do not provide much, if any, yield protection. If infection is severe early on the lower leaves, then spraying before last leaf emergence may be warranted. Most damage is done when infection is high during heading and flowering. In general, fungicides provide about two to three weeks of protection from further infection. Profitable returns from more than one spraying are highly unlikely, so it is imperative that the one application occurs at the optimal time. It is important to remember that fungicides are a preventative measure rather than a cure to the problem. Also, spraying will not increase yields, but will help preserve the yield potential that already exists in the field. Preventing yield loss should be the goal of a fungicide program, not enhancing yield beyond what is expected under favorable, non-diseased conditions. Research in Oklahoma and Texas indicates that yield protections of 10–30% can be achieved with fungicides. Unfortunately, it is difficult to predict exact benefits from spraying fungicides from one situation to the next due to the variability of contributing factors listed above. However, Table 2 provides a calculation of a cost-benefit evaluation that can be used to give general estimates of net returns and economic feasibility of fungicide treatment.

If it is determined that too much damage has occurred for adequate grain production and spraying fungicide is not feasible, other management options are available to producers. Baling for hay or cutting silage are avenues of harvest that may help salvage the crop, especially if demand exists in a region with large numbers of livestock (e.g., dairies and feedyards). Rust pustules are not toxic to ruminant animals grazing wheat pasture or consuming hay or ensiled wheat that was infected before cutting. However, forage quality and palatability of rusty hay or ensilage may be compromised due to extensive desiccation and wilting of damaged leaves. Also, rusty hay may lead to respiratory problems in horses. Moderate yield losses and nutritive value reductions should be anticipated when severely infected stands are cut for forage. When harvesting for feeding purposes, wheat should be cut at boot stage (Feekes 10.0–10.1) to optimize both yield and quality under ideal conditions. Oftentimes, it is well beyond this point that growers realize that rust damage is too severe for grain harvest, and nutrient content is reduced even more due to late cuttings.

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**Revised April 2016** **Las Cruces, NM**