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Stripe Rust of Small Grains

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Summary

Stripe rust was reported for the first time on barley in Arizona in 1993. Stripe rust could develop into a serious disease in Arizona if it becomes established on native grasses and weather conditions allow the fungus to proliferate. The disease is caused by the basidiomycete fungus *Puccinia striiformis.* Stripe rust appears as yellow orange stripes between the veins of the leaf blades. The disease increases water use, shrivels the grain, and decreases yield. The fungus is an obligate parasite because it can survive and reproduce only on live hosts. Mild winters and cooler wet weather in the spring favor development of the disease. Host plant resistance is the most effective means to manage the disease. However, the fungus evolves rapidly and different races can occur from one year to the next and might overcome resistance. A number of fungicides are labeled to control the disease but scouting and early detection are crucial for timely applications of fungicides to achieve effective control.

Introduction

Stripe rust or yellow rust, caused by the fungus *Puccinia striiformis*, is an important disease of wheat, barley, rye, triticale and certain other grass plants, especially in cool climates. This pathogen has become specialized to various degrees on these hosts. *Puccinia striiformis* f. sp. *tritici* attacks wheat and has numerous physiological races. A separate special form (formae specialis) of this fungus (*P. s.* f. sp. *hordei*) attacks barley. Stripe rust has emerged as the largest biotic limitation to wheat production worldwide. It is currently estimated that 88% of world's wheat production is susceptible to stripe rust, causing annual global losses of 5 million tons of wheat with a market value of 1 billion dollars. The fungus evolves and migrates rapidly on a global scale by long-distance wind dispersal and human means. Sexual reproduction of the stripe rust fungus mainly occurs in the Himalaya region including Nepal, Pakistan, and northwestern part of China. Asexual production of spores predominates in the Mediterranean and Middle East, although sexual reproduction does occur erratically. However, the stripe rust pathogen reproduces completely by asexual spore production on infected wheat and barley in all other regions including the Americas, Africa, and Australia. Stripe rust was first introduced into the western United States in the early 1900s. A second introduction to the western United States in 1993 has spread to more than 20 states from coast to coast. Stripe rust is most destructive in the Pacific Northwest and increasingly poses a great threat to the south-central states and the Great Plains. In Arizona, the first stripe rust outbreak occurred on barley in Pinal County in 1993. Since then, the disease has not been of great concern to small grain production in Arizona because stripe rust is a cool season disease and warm spring temperatures in Arizona usually diminish the risk of severe disease development and yield losses. However, in the 2017 crop season, significant stripe rust infections on wheat were observed in Yuma County. Recent research provides evidence that the fungal populations have changed and the new population is more aggressive, producing more spores, and better adapted to higher temperatures. Therefore, stripe rust is likely to become more common in Arizona.

Symptoms

Symptoms of stripe rust can be variable, depending on the resistance level of cultivars affected. Early season infections in Arizona are believed to be initiated by long-distance dispersal of spores carried on wind currents from Mexico. The first sign of stripe rust is the appearance of leaf chlorosis with yellow streaks (pre-pustules) (Fig. 1a), followed by long stripes of small, bright yellow, elongated uredial pustules on the leaves and leaf sheaths (Fig. 1b and 1c). Similar symptoms can be noted on awns and inside of glumes. Yellow spores accumulate on grains but kernels are not infected (Fig. 1d). Mature pustules will produce massive amounts of yellow-orange uredospores that are easily dislodged. In some moderately resistant varieties, long, narrow yellow stripes will develop on leaves and the infected tissues will have more of a brown or tan coloration (Fig. 2). Grain yield reduction is caused by the loss of green leaf area used for photosynthesis and water loss through evaporation due to the destruction of the leaf epidermal layer.

Three rust pathogens attack wheat and barley: stripe rust, leaf rust, and stem rust. Symptom resemblance between rusts can complicate diagnosis, especially at late infection stage when all three rusts can produce black spores (teliospores, thick-walled spores specialized for survival) on mature plants. In general, these three rusts can be distinguished based on color, shape, and location on the plant. Stripe rust are yellow with small circular pustules densely packed in yellow stripes running in parallel along leaf edge, located mainly on the upper surface of leaf, leaf sheaths, awns and glumes (Fig. 1b-1d). In contrast, leaf rust is orange brown, circular to oval in random pattern on leaf, located mainly on upper surface of leaf and leaf sheaths (Fig. 3a). Stem rust is reddish brown, oval to elongated with tattered edges in a random pattern on both sides of the leaf, on leaf sheaths, stems and outside of wheat spike (Fig. 3b-3d). In addition, rusts are easy to distinguish from other wheat diseases such as bacterial leaf streak and Septoria leaf blotch, when the rust pustules are young, but it can be difficult to distinguish rust from these two diseases and other abiotic disorders if the leaves have died and have become brown and dry.

Disease Cycle

The life cycle of stripe rust includes five spore stages on two hosts: wheat and barley as primary hosts and barberry (*Berberis vulgaris*) as alternate host. However, in-season rust cycles in Arizona are simple because the barberry has not be found and three of the five spore stages are of little importance for in-season rust development. In Arizona, the uredospore (thin-walled spores specialized for repeating infection) is the spore type that can cause autoinfection (spores infect the same plants on which they were produced) and are responsible for dispersal and infection of the wheat crop. In spring, air currents carry uredospores from Mexico into Arizona or locally from plant to plant and from field to field. Spores land, germinate and infect leaves of susceptible wheat plants. After penetration, fungal mycelia (vegetative part of the fungus consisting of thread-like hyphae) elongate beneath the surface of the leaf and stem. New uredospores develop in pustules that erupt through the leaf surface releasing massive amounts of spores into the air. These airborne spores can serve as a source of initial infection through long distance wind dispersal or as the repeating stage on the same host, leading to rapid

Fig. 1. Symptoms of stripe rust at various stages: a: pre-pustule stage with leaf chlorosis; b and c: mature stage with distinctly yellow-orange rust pustules on leaves and leaf sheaths; d: yellow-orange uredospores on awns and glumes (Image courtesy of N Goldberg and E DeWolf)

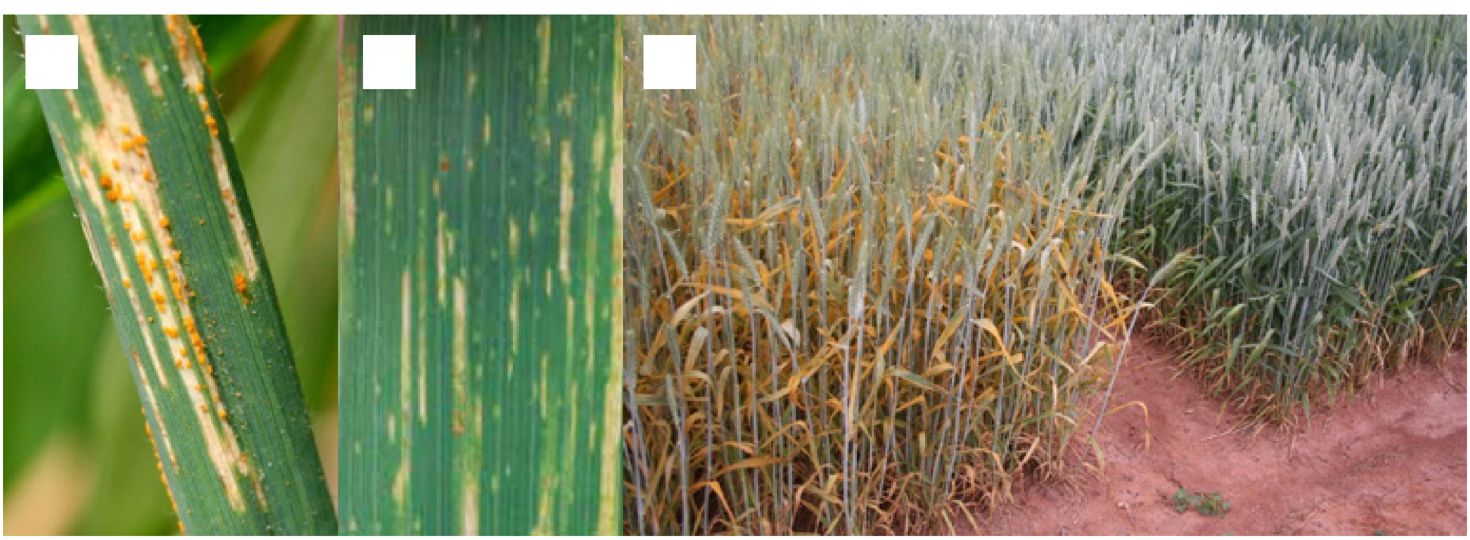

Fig. 2. Symptoms of stripe rust on, a: moderately resistant cultivar; b: resistant cultivars; c: susceptible and resistant cultivars in the field (Image courtesy of J Buck and E DeWolf)

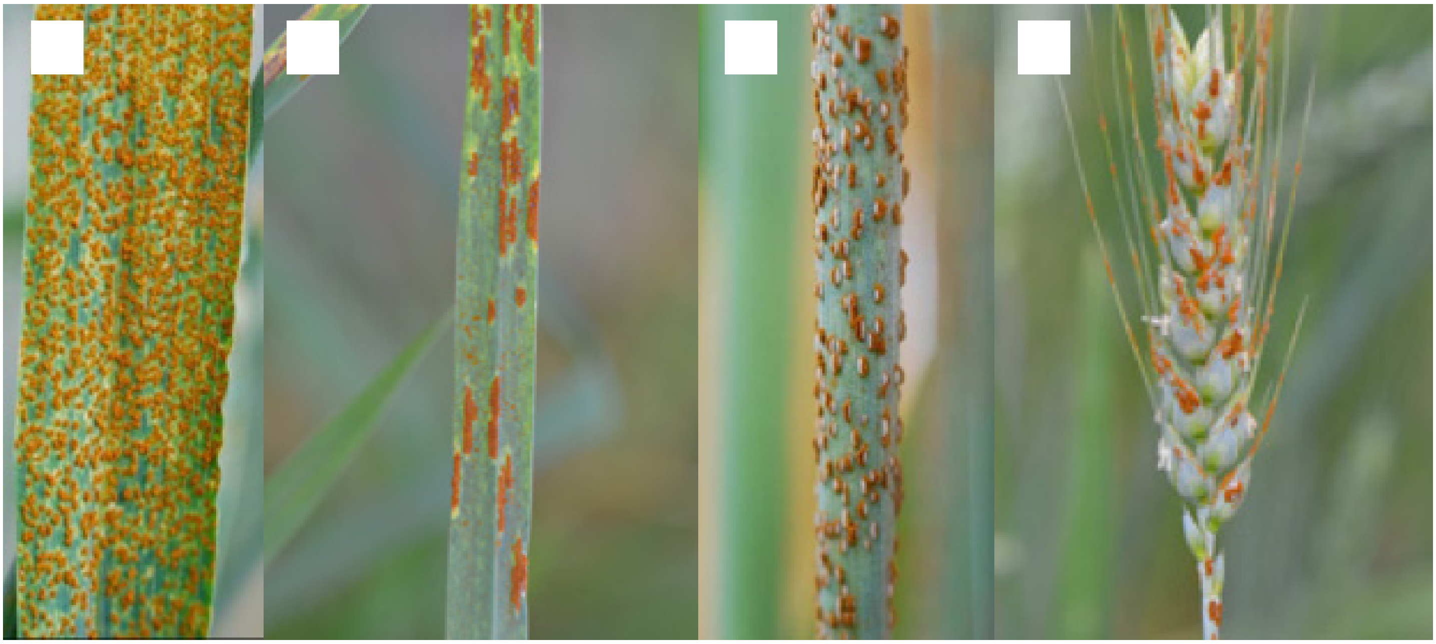

Fig. 3. Symptoms of a: leaf rust; b: stem rust on lower leaf surface; c: stem rust on stem; d: stem rust on the outside of spike (Image courtesy of E DeWolf and S Wegulo)

development of disease outbreaks. The annual progression of rusts across regions and continents is well known. Spores can also adhere to clothing and travelers can inadvertently carry and spread them. The yellow uredospores in the pustules are replaced by black teliospores later in the season. The teliospores are not important because they cannot infect any known alternate hosts and are thought to play no role in the infection process. It is not clear whether the fungus can oversummer in volunteer wheat plants in Arizona.

Environmental Requirements for Disease Development

High leaf surface moisture is required for the infecting spore to germinate and temperatures must be between 32 and 70 ºF (40 to 60 ºF is optimum). Infection occurs within 6 to 8 hours under optimum conditions. Infection rarely occurs below 36 ºF and tends to cease above 73 ºF. Disease development is most rapid and secondary spores can be produced in 7 to 10 days if temperatures are between 50 and 60 ºF and adequate moisture is available. Intermittent rain or heavy dew can accelerate the development and spread of the disease. The fungal mycelium in green leaf tissue can survive temperatures as low as 23 ºF. The disease can progress rapidly since a 10,000 fold increase in spores is possible in one generation. In the deserts of Arizona below 4000 ft, stripe rust on winter wheat is first observed in late winter or early spring.

Disease Management

The overall goal of stripe rust management is to minimize yield loss by protecting the flag leaf and the second leaf. This goal is achieved by reducing the rate of disease progression and thus delaying the onset of the epidemic. Specifically, stripe rust can be managed by a combination of resistant cultivars, seed treatment and foliar fungicide sprays:

1) Planting the most resistant cultivars. The latest information on the response of wheat varieties to stripe rust and other important diseases is updated in each year's Guidelines for Small Grains Growers released by the University of California, available at http://smallgrains.ucanr.edu/Variety_Results/. However, It is important to point out that stripe rust race composition in Arizona might be different from that in California.

2) Planting seed treated with Baytan or other triazole fungicides will protect plants for approximately 40 days. Nitrogen fertility status of the crop is important since plants high in nitrogen content are more susceptible to stripe rust.

3) Applying a foliar fungicide at the boot stage of development. If rust develops, a second fungicide application 20 days after the first may be required. Products belonging to the strobilurin class (Headline and Quadris) have excellent protective activities against stripe rust when applied before infection. If stripe rust is present at the time of application, use of triazole fungicides (Tilt, Folicur, Prosaro) or premixes of the two classes (Quilt, Stratego) is recommended as the triazole class of fungicides is thought to have stronger curative activity. For best results, these products should be applied before stripe rust becomes well established in the crop.

4) Monitoring crop for stripe rust. The decision on whether or not there is need to treat depends on the timing of first finding of stripe rust. It may be better to start checking for early winter infection on a bi-weekly basis during winter, changing to weekly inspection in spring as the potential for stripe rust development increases.

Resources

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