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Chapter 7

Important Wheat Diseases in Arkansas and Their Management

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Wheat diseases are caused by pathogenic microorganisms such as fungi, bacteria, viruses and nematodes. Disease occurs when one or more of these pathogens infect a susceptible variety and environmental conditions are favorable for disease development. Some diseases are relatively easy to diagnose because symptoms are characteristic and obvious. Experience with wheat in your area and on your farm may allow you to diagnose many of the common wheat diseases without additional help. A small, inexpensive hand lens with about 10X magnification can be useful in many diagnoses. Other diseases, however, may be difficult to diagnose without microscopic or laboratory analysis. An accurate diagnosis of the problem is the first step toward achieving satisfactory management.

When in doubt, your local county Extension agent should be your first resource for obtaining an accurate diagnosis and selecting appropriate management practices. County agents can identify many problems and can submit a sample to the Plant Health Clinic for further analysis. The following sections are intended as a guide to understanding how the various diseases develop and to help diagnosis and select effective management practices for the principal wheat diseases in Arkansas.

Foliar and Head Diseases

Stripe rust, caused by the fungus *Puccinia striiformis* f. sp. *tritici*, has been the most important foliar disease in Arkansas since 2000 when a new aggressive strain was identified. Compared to the old strain that was present before 2000, the new strain causes more disease more quickly and is adapted to warmer temperatures which allows stripe rust to continue to develop until near the end of the season. Since its initial discovery in Arkansas, the new strain has caused serious epidemics on five continents including regions that had never seen stripe rust.

In Arkansas, initial infections typically occur during the fall from spores that likely are blown from the Highlands of Mexico where spring wheat is grown at high elevations during the summer. These infections develop during the winter when the temperature is above 35°F and generally survive the winter if the infected leaf survives. The infections develop into "hot spots" during the winter (Figure 7-1). Hot spots are unique to

Figure 7-1. Stripe rust hot spot. *Photo by Travis Faske, UA Division of Agriculture*

stripe rust because spores produced on lower leaves during the winter clump together under the high humidity present within the wheat canopy. Because the spores are clumped, they do not travel far, and subsequent infections are within a small area around the initial infection that becomes totally diseased. Once stripe rust breaks out of the wheat canopy, the spores are blown across the field and to other fields near and far. Applying a fungicide to fields with hot spots soon after detection is a critical step in managing stripe rust.

Symptoms on upper leaves appear as long yellow stripes containing masses of yellow powdery spores (Figure 7-2). However, symptoms on lower leaves during the winter are not in stripes, and spores are produced across the entire leaf width (Figure 7-3). The fungus grows systemically within leaves such that one infection can colonize an entire lower leaf. On upper leaves, the fungus is usually restricted by leaf veins, producing distinct stripes. With the old strain, stripe rust was considered a cool-season disease that stopped developing when night temperatures approached 60°F. However, the new strain tolerates night temperatures to about 65°F and quickly resumes growth if night temperatures become cooler. In addition to favorable temperatures that usually occur from October through early May, stripe rust needs free moisture in the form of dew for spores to germinate and infect. Dew periods longer than 6 hours promote infection.

Growing resistant varieties is the best method for avoiding losses caused by stripe rust. However, the predominant type of resistance in contemporary varieties appears to be race-specific adult plant resistance for which plants are susceptible through jointing stage and become resistant as they mature. This allows stripe rust to develop during winter months even if plants become resistant later in the season. Furthermore, the pathogen frequently evolves to overcome this type of resistance, so it is important to use current information on stripe rust reactions that can be found in the most recent edition of the *Wheat Update* (http://www.uaex.uada.edu/farm-ranch/crops-commercial-horticulture/wheat/), published annually by the Arkansas Cooperative Extension Service, and to scout fields during late winter and early spring.

Stripe rust can be managed with most of the fungicides that are registered on wheat. Timing of an application is usually more important than the particular fungicide used. Once hot spots are found in a field, the field should be sprayed as soon as possible. Although new spores will continue to be produced for several days after a

Figure 7-2. Stripe rust pustules.
Photo by Jason Kelley, UA Division of Agriculture

Figure 7-3. Stripe rust pustules early in the season.
Photo by Jason Kelley, UA Division of Agriculture

fungicide application, research in Arkansas has shown that the fungicide quickly inhibits the ability of spores to infect plants and the spread of stripe rust is stopped. If stripe rust is spreading into a field without hot spots, it is important to spray sooner rather than later. However, it also is important to protect the flag leaves from infection. Early boot stage when the flag leaf first becomes fully expanded is usually an effective time to apply a fungicide if only one application will be made. If stripe rust has already infected the flag leaves, it is important to use a triazole fungicide rather than a strobilurin fungicide because the triazoles have better post-infection activity to stop systemic spread within leaves. Consult the most recent edition of the Extension publication MP154, *Arkansas Plant Disease Control Products Guide*, available at www.uaex.uada.edu, for more information on current fungicide recommendations.

Leaf rust, caused by the fungus *Puccinia triticina*, is common in Arkansas and appears on the upper surface of leaves as dusty, reddish-orange pustules about 1⁄16 inch in diameter (Fig-ure 7-4). Leaf rust is commonly found during the fall, but this is not cause for alarm. The fungus requires a living host plant to reproduce, and if infected leaves die during the winter, the fungus will die too. The probability of surviving overwinter increases if a leaf is only lightly infected and temperatures are mild. Usually the leaf rust fungus does not survive well over winter in Arkansas. Leaf rust commonly develops after wheat heading from spores that blow in from Louisiana, Texas or Mexico where the pathogen has a better chance of overwintering and wheat growth is ahead of that in Arkansas. Daytime temperatures around 70°F and heavy dew in the mornings favor leaf rust. Because leaf rust usually develops late in the season, it generally does not cause as much yield loss as stripe rust.

Figure 7-4. Leaf rust pustules.

Photo by Jason Kelley, UA Division of Agriculture

Resistant varieties are the best and most economical means of control, and most contemporary varieties have effective resistance. The most common type of resistance tends to be race specific, meaning that it is effective against some races (strains) of the fungus and ineffective against other races. The major races in Arkansas may change from year to year, and a variety that was resistant last year may not be resistant this year. Consult the disease reaction of adapted varieties in the latest issue of *Wheat Update* (http://www.uaex.uada.edu/farm-ranch/crops-commercial-horticulture/wheat/).

Fungicides can be used to control leaf rust when cultivars lack adequate resistance. Most foliar fungicides that are registered on wheat are very effective for controlling leaf rust and other diseases on the leaves in the spring if they are properly applied. Consult the most recent edition of MP154, *Arkansas Plant Disease Control Products Guide*, for more information on current fungicide recommendations.

Septoria tritici blotch (speckled leaf blotch) is caused by *Septoria tritici* and usually can be found in nearly all wheat fields in Arkansas. Initial infections are caused by spores that are produced on wheat residue from the previous year and infected volunteer wheat. Cultural practices such as crop rotation and tillage to destroy volunteer wheat and bury crop debris can reduce the number of initial infections. *Septoria tritici* is not seedborne so chemical seed treatment is not effective. Symptoms are usually first seen in late winter on the lowest leaves that are in contact with soil and progress up the plant during the season as environmental conditions permit. Disease is favored by frequent rain, high humidity and temperatures of 65° to 75°F. Lesions begin as small reddish-brown spots between the leaf veins. Older lesions are irregular in shape with more or less parallel sides and centers that become ash colored and eventually die, turning light gray to tan in color (Figure 7-5). Several lesions may grow together and kill large areas of leaves.

Figure 7-5. Septoria tritici blotch.
Photo by Jason Kelley, UA Division of Agriculture

Septoria tritici produces numerous black pycnidia that are readily visible to the unaided eye in the dead centers of lesions. Pycnidia occur in rows, appear as tiny, raised black dots and produce the spores that are responsible for new infections. Under wet conditions, off-white masses of spores ooze from the top of the pycnidia and are splashed by rain to other leaves and nearby plants.

Wheat varieties vary in their level of susceptibility to Septoria tritici blotch, but none are totally resistant. Disease develops more slowly on moderately resistant varieties than on moderately susceptible or susceptible varieties. Consult the disease reaction of adapted varieties in the latest issue of *Wheat Update* (http://www.uaex.uada.edu/farm-ranch/crops-commercial-horticulture/wheat/).

Registered fungicides are effective against Septoria leaf blotch when applied in a timely manner that protects the flag and flag-1 leaves for as long as possible. Consult the most recent edition of MP154, *Arkansas Plant Disease Control Products Guide*, for more information on current fungicide recommendations.

Stagonospora nodorum blotch (glume blotch) is caused by *Stagonospora* (formerly *Septoria*) *nodorum*. Initial infections can come from infected seeds and from airborne and rain splash-dispersed spores produced on the residue of previous wheat crops. The fungus attacks all aboveground parts of the plant. Lesions on leaves are more oval- or lens-shaped than those caused by *S. tritici* (Figure 7-6). The center of the lesion may be gray to brown and is usually surrounded by a pale yellow halo. Lesions may coalesce to kill large areas of leaf tissue. Stem infections, especially at the nodes, are also common. Lesions on the glumes usually begin at the tips and develop into brownish-purple streaks and blotches (Figure 7-7). Grain will be shriveled in heavily diseased heads, and this close association with developing seeds causes the pathogen to become seedborne. Reddish-brown pycnidia, appearing as small pimples, develop in the center of the lesions but are more difficult to see than those of *S. tritici* because they are less numerous and are embedded in the plant tissue. Pinkish masses of spores may ooze from the tops of pycnidia under moist conditions. Leaf lesions may be confused with Septoria tritici blotch and tan spot, and glume lesions may be confused with black chaff.

Research in Arkansas has shown that *S. nodorum* infects many of the lower leaves and leaf sheaths early in the season without causing noticeable symptoms. Consequently, scouting

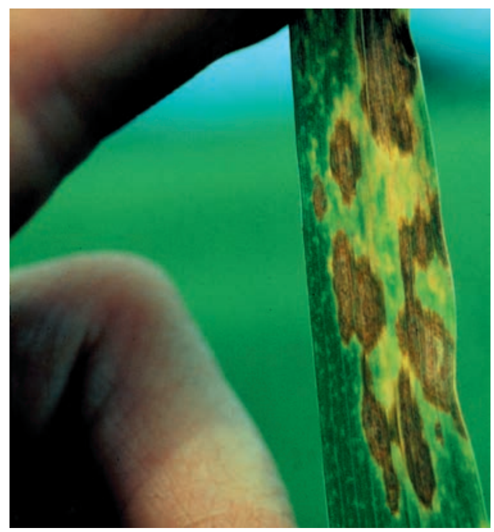

Figure 7-6. Stagonospora nodorum blotch.
Photo by Gene Milus, UA Division of Agriculture

Figure 7-7. Glume blotch symptoms.
Photo by Gene Milus, UA Division of Agriculture

for symptoms before heading is likely to underestimate the level of infection; i.e., for each visible lesion there are about 20 symptomless infections. The fungus becomes much more aggressive as plants approach heading. The fungus grows faster and produces more spores as infected lower leaves die, providing the potential for an abundance of spores at heading time. Disease severity is greater with frequent rainfall, high humidity and temperatures in the mid-70s.

Control measures are similar to those for Septoria tritici blotch (see above), except that fungicide seed treatment may be an effective means of control. Research in Arkansas found that seed treatment with Dividend fungicide (now Dividend Extreme, 0.77 lb ai/gallon difenoconazole and 0.19 lb ai/gallon mefanoxam) can provide better control than an application of Tilt foliar fungicide (3.6 lbs ai/gallon propiconazole) at flag leaf emergence stage of growth.

Bacterial streak (black chaff), caused by the bacterium *Xanthomonas translucens*, is a sporadic disease that attacks all aboveground parts of the plant. Initial infections originate from infected seeds. Research in Arkansas has shown that cells of the bacterium on or within seed can be transferred to the first leaf where they multiply to high populations. Splashing rain disperses the bacteria to new leaves and provides favorable conditions for bacterial multiplication and disease development. The bacterium can multiply to high populations on the surface of leaves before the first symptoms appear. Bacterial cells enter the plant through stomata, hydathodes (pores at the tips of leaves that discharge drops of water), and wounds and then multiply inside the plant. Symptoms first appear on leaves as small water-soaked brown spots at the edge of leaves or between the veins that elongate quickly. These elongated lesions (Figure 7-8) are the basis for the name "bacterial streak." Under a microscope, masses of bacteria can be seen to stream from cut ends of a lesion, and this can be used as a diagnostic tool for identification. Under Arkansas conditions, symptoms are most conspicuous shortly after flowering when a flush of symptoms appears quickly on upper leaves with little evidence of an upward progression of symptoms. Lesions may grow together to kill large areas of a leaf and soon turn dry and brown. Dried bacterial exudate, usually in the form of thin transparent scales, may be associated with some of the lesions. Under hot, dry conditions the streaks will dry and turn brown in a few days. Saprophytic fungi may sporulate in the old lesions to mask the bacterial streak symptoms. It is important to distinguish bacterial streak from fungal diseases because foliar fungicides will not control bacterial streak.

Figure 7-8. Bacterial streak on flag leaf.

Photo by Jason Kelley, UA Division of Agriculture

The bacterium causes black elongated lesions on peduncles (portion of the stem just below the head) (Figure 7-9) and glumes, and these are the basis for the name "black chaff" (Figure 7-10). Black chaff may be confused with glume blotch in the field, but the two diseases can

Figure 7-9. Bacterial streak on peduncle.

Photo by Jason Kelley, UA Division of Agriculture

Figure 7-10. Black chaff on glumes.

Photo by Gene Milus, UA Division of Agriculture

Figure 7-11. Stem rust pustules.

Photo by Jason Kelley, UA Division of Agriculture

be distinguished by the presence (glume blotch) or absence (black chaff) of pycnidia. As with glume blotch, diseased stems and heads are associated with shriveled seeds and seedborne bacteria.

Wheat varieties differ in susceptibility to bacterial streak and black chaff, and planting resistant varieties is the best means of control. Unfortunately, there is little information on levels of resistance among contemporary varieties of soft red winter wheat. Planting seed with low levels of seedborne inoculum would be a good means of control; however, there is no means of certifying the inoculum level in seeds. Avoid varieties that have unacceptable levels of disease and do not plant seeds from fields with moderate to severe bacterial streak or black chaff symptoms. Chemical bactericides are not effective means of control.

Stem rust, caused by *Puccinia graminis* f. sp. *tritici*, may be found somewhere in Arkansas each year but rarely causes serious damage because it develops about the time plants are senescing. Stem rust requires warmer temperatures than either stripe or leaf rusts. Symptoms appear as large, dark red pustules that burst through the epidermis on stems, leaf sheaths, leaves and even glumes (Figure 7-11). Stem rust can be distinguished from leaf rust because the pustules sporulate on both sides of a leaf, have torn pieces of the epidermis evident at the margins and can be three to four times larger than leaf rust pustules.

Wheat varieties resistant to stem rust are available, but the disease is so sporadic that little information on the level of resistance in contemporary varieties is available, and stem rust resistance should not be a high priority in variety selection. Avoiding very susceptible varieties should be sufficient in most cases. This disease develops too late for foliar fungicides to be feasible, but fungicides applied earlier to control other diseases likely will have some residual effect against stem rust.

Powdery mildew, caused by the fungus *Blumaria graminis* f. sp. *tritici*, is commonly found on lower leaves during the late winter and early spring. Initial infections develop from sexual and asexual spores produced on residue from previous wheat crops. Symptoms appear on leaves and leaf sheaths as tufts of off-white cottony mycelium that can be rubbed off. Leaves are pale yellow beneath the mycelium. The fungus produces asexual spores on the mycelium and sexual spores in black fruiting bodies that may develop later in the mycelium (Figure 7-12). Powdery mildew is favored by heavy nitrogen fertilization, thick lush stands and cool humid weather. Under Arkansas conditions, the disease can be found in many fields during stem elongation stage, but in most cases it tends to disappear as the season progresses.

Figure 7-12. Powdery mildew pustules.

Photo by Travis Faske, UA Division of Agriculture

Most contemporary varieties grown in Arkansas appear to have adequate resistance to powdery mildew. However, there are races of the powdery mildew fungus just as there are races of the rust fungi. New races may develop to cause disease on varieties that are now resistant. Powdery mildew can be controlled by all registered fungicides, but fungicide applications are rarely necessary.

Tan spot, caused by the fungus *Pyrenophora tritici-repentis*, usually is a problem only when wheat is grown after wheat in a no-till or minimum-till cropping system. Initial infections are from sexual spores produced in fruiting bodies on infected stems from the previous wheat crop. These black fruiting bodies are large enough to be easily seen and feel like rough sandpaper when an infected stem is pulled between a thumb and finger. Finding these fruiting bodies on the crop debris is a good means of diagnosis because these should be present if tan spot is a problem in a field. Symptoms first appear on lower leaves as tan-brown spots, which expand into elliptical tan blotches with yellow borders as immature lesions. Several lesions may grow together to kill large areas of a leaf, and the lesions become darker as they mature because of the production of dark brown spores in the center of the lesions. Symptoms on leaves may be confused with Septoria leaf blotch or Stagonospora blotch, but no pycnidia are produced in tan spot lesions. A circular tan spot with a sharp margin caused by paraquat (Gramoxone) herbicide drift is often mistaken for tan spot, but the distribution of symptoms does not fit the distribution of tan spot symptoms which is from lower leaves to upper leaves.

Tan spot is favored by continuous wheat production and minimum tillage where excessive crop debris remains in the field. Inoculum on crop debris can be readily reduced by crop rotation and tillage to bury and decompose the crop debris. Resistance levels of contemporary varieties are not known. Foliar fungicides are effective against tan spot. Consult the most recent edition of MP154, *Arkansas Plant Disease Control Products Guide*, for more details on fungicides.

Loose smut, caused by the fungus *Ustilago tritici*, is strictly a seedborne disease. Infections occur during flowering when spores from smutted heads enter florets of healthy heads and germinate to infect the developing seed. The fungus remains dormant in the seed until the seed germinates. Infected seeds cannot be distinguished from healthy ones without laboratory analysis. After the seed germinates, the fungus remains associated with the growing point until it invades the developing head. By heading stage of growth, infected plants are shorter and head a few days earlier than healthy plants. Although symptoms are very obvious at heading because all of the seed heads on infected plants are replaced by masses of dark brown, powdery spores (Figure 7-13), infected plants are commonly located in the lower canopy since the smutted heads are always on stunted plants. The spores soon blow away to infect healthy florets, leaving a bare rachis (portion of the stem that holds the florets).

Figure 7-13. Loose smut of wheat.

Photo by Travis Faske, UA Division of Agriculture

Although some varieties may be resistant, planting treated wheat seed has become the preferred method of control. Several seed treatments containing triazole fungicides are effective at preventing the pathogen contained in infected seed from becoming established in the growing point of the seedling. However, none completely eliminate loose smut. Several generations of seed production may need to be treated to completely eliminate the loose smut fungus from infected seed lots. Seed production fields should be located away from infected fields since spores can be blown a mile or more to infect the florets. Consult MP154 for currently available wheat seed treatment fungicides.

Fusarium head blight (Scab) is caused primarily by *Fusarium graminearum* along with several other *Fusarium* species and is a sporadic disease that has potential to cause huge losses such as those that occurred in Arkansas in 1990 and 1991. The disease is favored by warm temperatures, frequent rainfall and high humidity before, during and after flowering. Infections occur at or shortly after flowering. Symptoms occur on the head a few days after infection. Individual spikelets or the entire inflorescence (i.e., seed head) appear prematurely bleached (Figure 7-14). Pink or orange spore masses may be seen at the base of blighted spikelets. The bleached spikelets usually contain shriveled scabby seed (tombstones) (Figure 7-15). Brown or black lesions may be present where the head joins the stem.

Figure 7-14. Fusarium head blight of wheat (scab).
Photo by Jason Kelley, UA Division of Agriculture

Figure 7-15. Fusarium head blight-infected wheat kernels.
Photo by Travis Faske, UA Division of Agriculture

Scabby grain may contain one or more toxins (commonly referred to as vomitoxin) such as deoxynivalenol (DON) or nivalenol that are produced by *Fusarium* species and may be docked at the elevator. Scabby grain is lightweight and can be separated from the healthy grain by increasing airflow in combines at harvest. Scabby grain should not be fed to livestock, especially hogs, because of potentially lethal effects.

Fusarium graminearum also causes stalk and ear rot of corn, stalk rot and panicle blight of sorghum, and scab of rice, so rotations involving these crops can increase the risk of disease. Cultural practices, such as tillage to bury crop debris and crop rotation to allow time for residue decomposition, can reduce the amount of initial inoculum. However, *Fusarium* species are ubiquitous, and high numbers of spores will be airborne over long distances, especially from corn stubble, when conditions are favorable.

Although no variety is completely resistant, planting moderately resistant varieties is important for reducing the risk of scab. Planting several varieties with different flowering times (maturities) is a way to escape severe scab in at least part of a crop because it is unlikely that all of the varieties will flower when conditions are favorable for infection.

Caramba and Prosaro fungicides are the most effective against scab and can provide about 50% suppression of disease symptoms and losses when applied between the beginning of flowering and a few days after the completion of flowering. It is important that fungicides be applied directly and as uniformly as possible to heads because fungicide is not translocated from leaves to heads. A number of resources for managing Fusarium head blight are available through the U.S. Wheat and Barley Scab Initiative at http://www.scabusa.org/. From this website, one can access a scab forecasting service that uses local weather data to predict scab epidemics, sign up for scab alert messages via text messages or email and find information on resistant varieties and fungicides via ScabSmart.

If a scabby seed lot must be used for planting, as much of the lightweight seed as possible should be removed and a fungicide seed treatment should be applied. The seed treatment will improve seed germination and seedling vigor but will have no effect on head blight the next year. Consult MP154 for more details.

Downy mildew (crazy top), caused by the fungus *Sclerophthora macrospora*, frequently occurs in areas of fields that are subject to flooding. The fungus attacks wheat, oats, barley, rice, corn, sorghum and about 140 species of wild grasses. All wheat varieties are susceptible. The fungus produces thick-walled survival spores within infected tissue. Under flooded conditions these germinate to produce other spores that "swim" in water. These motile spores penetrate submerged leaf sheaths and infect the plant. Seedlings are more susceptible than adult plants.

Symptoms appear in the spring as stunted yellow plants. Leaves of infected plants feel thick and leathery. Severely stunted plants produce many tiny stems and usually die before heading. Less severely infected plants may produce distorted heads with no grain that resemble plants affected by phenoxy herbicide damage, and these plants usually remain green long after healthy plants have matured (Figure 7-16).

Figure 7-16. Downy mildew of wheat (crazy top).
Photo by Jason Kelley, UA Division of Agriculture

Avoiding areas prone to flooding and providing adequate drainage of surface water are the best and only means of controlling downy mildew.

Sooty mold is caused by a number of saprophytic or weakly pathogenic fungi including *Alternaria*, *Stemphylium*, *Epicoccum* and *Cladosporium* species. Sooty mold is not considered a disease because it occurs only on plants that have matured or have been killed by other causes. Under wet or humid conditions these fungi rapidly colonize all aboveground plant parts turning them dark brown to black. No control is necessary. However, plants with sooty mold also may have grain with black point (see below). Sooty mold is occasionally mistaken for "smut," but with smut diseases the grain will be replaced by smut spores.

Black point (kernel smudge) is associated with wet, humid conditions between maturity and harvest and with a number of fungi (Figure 7-17). The discoloration of kernels is believed to be due to peroxidase activity on phenolic compounds that are released from damaged kernels. Harvesting before conditions are favorable for black point is the best means of avoiding the problem. Grain with black point may be discounted at the point of sale. Seed lots with black point likely will have improved germination and vigor if a seed treatment fungicide is applied.

Figure 7-17. Black tip of wheat.
Photo by Jason Kelley, UA Division of Agriculture

Virus Diseases

Soilborne **wheat mosaic** (SBWM, soilborne virus) is caused by *soilborne wheat mosaic virus* (SBWMV) that is transmitted to wheat by a soilborne protozoan, *Polymyxa graminis*, an obligate parasite in roots of many plants. The virus survives inside thick-walled survival spores of the protozoan. Infection occurs under cool, wet conditions when the survival spores germinate to release motile spores that "swim" through saturated soil and infect roots. The most severe symptoms (stunted plants, yellow leaves with mosaic pattern and low yield) are produced when infection occurs shortly after seedlings emerge in the fall. Symptoms from fall infection usually appear in late February or March as stunted, yellow plants and may be misdiagnosed as nitrogen deficiency. Upon close examination, leaves from diseased plants will have a yellow-green mosaic pattern (Figure 7-18). Plants infected in the spring likely will have mosaic symptoms but little stunting or yield loss. In some fields the disease may be limited to wet areas. However, under Arkansas conditions, the entire field may be affected. Temperatures from 50° to 68°F are favorable for disease development. Fall-infected plants will remain stunted throughout the season.

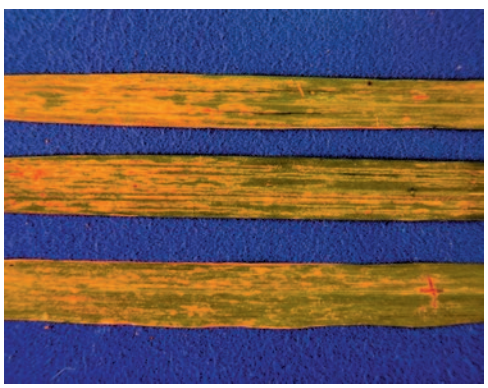

Figure 7-18. Severe wheat soilborne mosaic virus leaf symptoms.

Photo by Gene Milus, UA Division of Agriculture

Both SBWMV and its fungal vector survive in the soil for a long time and can be spread with soil from field to field by wind, water and farm machinery. In Arkansas, fields infested with SBWMV also tend to be infested with wheat spindle streak mosaic virus. Resistant varieties are the only feasible means of control, but little information is available on the resistance of contemporary varieties.

Wheat spindle streak mosaic (WSSM, wheat yellow mosaic, soilborne virus) is caused by *wheat spindle streak mosaic virus* (WSSMV) that is transmitted to wheat by the same protozoan that transmits *soilborne wheat mosaic virus*. In Arkansas, some fields are infested only by WSSMV while other fields are infested by both WSSMV and SBWMV. The biology of WSSM is similar to that of SBWM except that WSSM has a lower optimal temperature range (47° to 55°F). Symptoms include mild stunting of plants and yellow streaks in leaves. The streaks usually have tapered ends, making them resemble spindles (Figure 7-19). Symptoms disappear when temperatures stay above 65°F.

Figure 7-19. Wheat spindle streak mosaic virus leaf symptoms.

Photo by Gary Cloud, UA Division of Agriculture

WSSM causes less yield loss than SBWM. Planting resistant varieties is the only feasible means of control, but little information is available on the resistance of contemporary varieties.

Barley yellow dwarf (BYD) is caused by several species of related viruses, each of which is transmitted to plants by particular species of aphids. In Arkansas most BYD likely is caused by the PAV species that is vectored by the bird-cherry oat aphid. Initial infections occur in the fall, most likely by winged aphids that are blown long distances from unknown sources. Aphid feeding for 12 to 48 hours is required to transmit the virus to plants. Once a plant is infected, the virus replicates and spreads throughout the plant. Aphids are born virus-free but acquire the virus by feeding on an infected plant. As aphids multiply, wingless aphids spread to neighboring plants to feed. With each successive generation of aphids, the area of infected plants expands outward in all directions from the one plant that was infected initially, resulting in patches of diseased plants. Because infection of younger plants results in more severe stunting than infection of older plants, some patches are saucer-shaped with the most severely stunted plants near the center and progressively less stunted plants away from the center.

Symptoms of fall infection generally do not show until after regrowth starts in the spring. These symptoms include stunting, poor tillering, stiff upright leaves and yellow, red or purple coloring of leaves starting at the tip (Figure 7-20). Vivid yellow, red or purple coloration of the leaves may not show up until after an extended period of warm weather (usually in April). Before the characteristic leaf discoloration develops, symptoms can be mistaken for a root disease or nutrient deficiency. Stunted plants have small root systems and are more susceptible to drought stress. When plants are infected in the spring, there is little stunting and less yield loss than with fall infection, and the main symptoms are stiff, upright flag leaves and yellow, red or purple coloration proceeding from the tip to the base of leaves.

Although most wheat varieties are susceptible, a few are known to have moderate to high levels of resistance. Unfortunately, the BYD reactions of contemporary varieties are unknown. Control of BYD is based on preventing plants from being infected in the fall. Planting as late as practical will reduce the probability of fall infection. Certain seed treatment and foliar insecticides can reduce the incidence and spread of the virus by killing the aphid vectors, but it has been difficult to determine when these treatments will be cost effective.

Figure 7-20. Barley yellow dwarf symptoms.
Photo by Gus Lorenz, UA Division of Agriculture

Wheat streak mosaic is caused by *wheat streak mosaic virus* that is transmitted by the leaf curl mite. Symptoms generally appear in the spring and become more severe as the season progresses. Infected plants usually are stunted with discontinuous yellow streaks in the leaves. Leaves may be rolled up (pencil-shaped) due to the feeding of the mites. Microscopic, light green, cigar-shaped leaf curl mites usually can be found on leaves of infected plants.

Wheat streak mosaic has been found only in isolated instances in northeast Arkansas. The disease generally is associated with the presence of volunteer wheat between harvest in June and emergence of the next crop in the fall. Volunteer wheat is an ideal host for both mite and virus. Destroying volunteer wheat at least two weeks before planting should be sufficient to control wheat streak mosaic.

Soilborne Diseases

Take-all, caused by the fungus *Gaeumannomyces graminis* variety *tritici*, can be a severe problem in some Arkansas fields. Initial root infections occur in the fall from runner hyphae of the fungus that grow out of infected crowns and roots of previous wheat crops and certain weedy grasses. Under moist conditions, runner hyphae grow from plant to plant along the row via root bridges and eventually across rows, giving rise to patches of infected plants. The first aboveground symptoms show in the late winter to early spring as stunted chlorotic plants, but these usually are overlooked. The most obvious symptoms occur during the grain-filling period when severely infected plants die prematurely and turn white. These plants can be pulled easily from the soil because the roots are rotted, and the crowns and lower stems will have a characteristic shiny black color due to mycelium of the take-all fungus (Figure 7-21). These dead plants usually occur in irregular patches that show up in the same areas of a field and expand each year that wheat is grown. At harvest, the dead plants likely will be heavily colonized by sooty molds, giving them a dark brown to black appearance.

Figure 7-21. Take-all symptoms.

Photo by Jason Kelley, UA Division of Agriculture

Take-all is favored by continuous cropping of wheat, grassy weeds in fallow fields during the winter, soil pH above 6.0, nutrient deficiencies, ample soil moisture from emergence through heading stage and drought stress during the grain-fill period. Different management recommendations were developed for irrigated and dryland fields. For fields where irrigated summer crops can be grown, rotation out of wheat for one year is the best option. One year without wheat allows time for most of the take-all fungus in crop debris to die if there are no grassy weeds in the field during the fall, winter and spring that wheat is not grown. Rice is the best rotation crop because the take-all fungus does not survive well in flooded soil during the summer. For dryland fields, continuous wheat with summer fallow is the best option. Fallowed soil is hotter during the summer because it is not shaded by a crop. Higher soil temperatures accelerate the decomposition of infested crop debris and weaken the take-all fungus.

In addition to the above recommendations, the following recommendations apply to both irrigated and dryland fields. Maintain soil pH below 6.5 and do not apply lime before a wheat crop because take-all is always worse at high pH levels. Maintain a balanced fertility program that supplies adequate amounts of nitrogen, phosphorous and potassium, because vigorous plants can outgrow some of the effects of take-all. Later planting and a firm seedbed are less conducive to take-all than early planting and a loose seedbed. No varieties are resistant. Fungicides, including seed treatment fungicides, are not effective.

Pythium root rot, caused by several species of *Pythium* fungi, probably affects every wheat plant in Arkansas at some time during the season. Aboveground symptoms include poor seedling vigor, stunting, reduced tillering and delayed maturity. Diseased roots have soft brown lesions. Small young roots are attacked more frequently than large older roots. Pythium root rot is favored by cool, wet soils and crop debris remaining near the seed zone.

Pythium root rot is difficult to control because the pathogen is found in all agricultural soils. Planting high-quality seed in a well-drained seedbed is beneficial in establishing a good stand. High levels of soil phosphorus have been shown to reduce the severity of root rot. Metalaxyl or mefenoxam fungicide seed treatment controls some *Pythium* species but not others, may improve seedling vigor, but has not increased yield in Arkansas trials.

Common root rot, caused primarily by *Fusarium graminearum* and *Bipolaris sorokiniana* (formerly called *Helminthosporium sativum*) fungi, is found throughout Arkansas, but the amount of yield loss varies greatly from year to year. Both fungi cause brown lesions on seedling roots. Dark lesions on the subcrown internode (section between seed and crown) are typically caused by *B. sorokiniana*. Significant yield loss usually occurs only when the fungi move into the crown and lower stems. This phase of the disease is triggered by drought stress that lowers the water potential of the plant and allows the fungi to grow into the crown and lower stems. Symptoms of this phase show as prematurely dead plants scattered in fields. Crowns and lower stems will have brown (*Bipolaris*) or pink (*Fusarium*) discoloration.

No soft-red winter wheat varieties are resistant. Crop rotation and certain seed treatments may reduce the seedling phase of the disease but are not effective in reducing the later crown and lower stem phase. Management practices such as avoiding high seeding rates and high nitrogen rates control the later phase by reducing water stress in dry springs.

Rhizoctonia root rot, caused by *Rhizoctonia solani*, and **sharp eyespot**, caused by *Rhizoctonia cerealis*, have been occasional problems in Arkansas. *Rhizoctonia solani* causes reddish-brown root lesions that result in root ends having a tapered point where the lesion severs the root. Seedlings with infected roots may have stiff leaves that are a dull blue-gray color. *Rhizoctonia cerealis* infects the leaf sheaths near the base of plants and causes elliptical light brown or straw-colored lesions with dark brown borders on stems. These lesions may occur on the lower 12 inches of the stem and may cause the stems to lodge or prematurely ripen.

No highly effective control measures are available; however, Rhizoctonia root rot has been more severe with no-till planting than with conventional tillage seedbed preparation. Crop rotation for one year out of wheat should also reduce the disease.

Guidelines for Applying Foliar Fungicides

The economic return from applying a foliar fungicide to wheat will be influenced by a number of factors. These include the yield potential of the field, price of wheat, cost of the fungicide treatment, susceptibility of the variety, disease pressure, effectiveness of the fungicide and timing of the application. Fungicides function to protect the yield and quality potentials of wheat from losses caused by certain diseases. Therefore, fungicides will have the greatest effects on yield and quality (e.g., test weight) when certain diseases are present early enough in the season and at levels sufficient to cause significant losses. Under Arkansas conditions, fungicides have had the greatest benefits for managing stripe rust that develops during winter through late spring. Fungicides also have been useful for managing leaf rust, Septoria tritici blotch, Stagonospora nodorum blotch, powdery mildew and tan spot.

Contemporary foliar fungicides that are registered on wheat are in three classes according to their mode of action (see fungicide efficacy table in MP154). Triazoles are demethylation inhibitors and stop important steps in growth in a wide range of fungi. They can prevent new infections and are the best for stopping infections that have already occurred. Two triazoles are the most effective fungicides against Fusarium head blight (scab). Few species of fungi and no wheat pathogens have developed resistance to triazoles. Strobilurins or Quinone Outside Inhibitors stop the production of ATP, disrupting the energy cycle in a wide range of fungi. They are very effective for preventing infections but weak on post infection suppression of existing infections. They tend to increase the severity of Fusarium head blight and levels of mycotoxins in grain affected by Fusarium head blight by eliminating some saprophytic fungi that compete with the Fusarium fungi causing head blight. Several fungi, but fortunately no wheat pathogens in the United States, have developed resistance to strobilurins. Combination products that combine a triazole with a strobilurin or a succinate dehydrogenase inhibitor (SDHI) with a strobilurin have the advantages of both components and should help prevent the occurrence of fungicide-resistant strains.

Usually a fungicide application needs to be timed to keep the flag and flag-1 (top two) leaves healthy for as long as possible. Applications made before flag leaf emergence (Feekes growth stage G.S. 8) likely will "play-out" too soon to provide adequate protection until the end of the season. Applications made after flowering will be too late to obtain the full benefit of the fungicide. If a foliar fungicide is used to protect the flag and flag-1 leaves, it should be applied during the boot or heading stages. If hot spots of stripe rust are found in a field or if stripe rust is developing on upper leaves, an earlier application is justified. Tank-mixing a fungicide with a broadleaf herbicide application in the spring usually will be effective for stopping early stripe rust development and will save the cost of a separate fungicide application. If conditions are favorable for Fusarium head blight (scab) around flowering time, an application of Prosaro or Caramba may be justified. A forecasting model to predict when head blight is most likely to cause significant damage is available at www.scabusa.org and can be used to help determine if an application specifically for head blight should be made between flowering and a few days after flowering.

Except in the case of Fusarium head blight, fungicides are most effective when applied after disease is present on lower leaves but before the upper leaves and heads become infected. A common mistake is waiting until disease has already caused damage on the upper leaves or heads before making an application. Fungicides can protect plant parts from damage but cannot reverse damage that has already occurred. It is important to keep the upper leaves and heads relatively free from disease during the grain-filling period, but some disease late in the season will not greatly affect yield or test weight.

Guidelines for Using Seed Treatments

Fungicides used in current seed treatment formulations are in three classes. Triazoles include tebuconazole, difenoconazole, triticonazole and prothioconazole that have systemic activity against the fungi causing loose smut, Stagonospora blotch and some seedling diseases. Some triazoles also may have some suppression against rusts, powdery mildew and Septoria leaf blotch for a few weeks after planting, but this suppression is not high enough to be useful under Arkansas conditions. Phenlyamides are the second class of fungicides used as seed treatments and include metalaxyl and mefenoxam. One of these fungicides is included in most seed treatment formulations to control seedling disease caused by *Pythium* species. Succinate dehydrogenase inhibitors such as sedaxane and penflufen present fungi with a different mode of action that helps prevent resistance to fungicides.

In Arkansas, the greatest benefits from fungicide seed treatments are for controlling loose smut and Stagonospora blotch. Loose smut and Stagonospora blotch are seedborne diseases that tend to build up in seed lots that are not treated with an effective fungicide. None of the seed treatments are 100% effective against these diseases, but seed lots with very low to undetectable levels of infection can be produced by treating several generations of seed increase. Therefore, it is recommended that seed be treated with a product containing one of the triazole fungicides if the seed is used for seed increase.

A secondary but common use for seed treatments is to improve stand, seedling vigor and yield of wheat grown for grain. Increases in stand and seedling vigor may look good in the fall but do not always result in increased yield. Seed lots with black point or scabby seed likely would benefit most from seed treatments, but there is little data supporting consistent yield increases from treating healthy seed. Factors favoring a positive economic return for treating wheat seed for grain production include high yield potential, high grain prices, using saved seed from fields with loose smut and/or Stagonospora blotch, and planting under unfavorable conditions for stand establishment.

Refer to the most recent edition of MP154, *Arkansas Plant Disease Control Products Guide*, for more information on current fungicide recommendations.