UNIVERSITY OF ILLINOIS EXTENSION
College of Agricultural, Consumer and Environmental Sciences

report on
PLANT
DISEASE

RPD No. 102
October 1998

DEPARTMENT OF CROP SCIENCES
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

SOILBORNE MOSAIC AND YELLOW MOSAIC (SPINDLE STREAK MOSAIC) OF WINTER WHEAT

Soilborne wheat mosaic, caused by a soilborne virus, was first discovered in Madison County, Illinois, in 1919. At present, this disease is known to occur in over 50 counties in Illinois. It has been found as far north as Grundy, Kendall, Mercer, and Putnam counties and as far south as Monroe, Randolph, and Wabash counties. The disease occurs throughout the eastern and central United States as well as in Argentina, Brazil, China, Egypt, France, Italy, and Japan.

Figure 1. Plant showing soilborne wheat mosaic.

Losses in wheat yields vary from year to year due to the cultivars being grown, continuous cropping to wheat, strains of the virus, and environmental conditions favoring disease development. Soilborne mosaic is one of the few diseases of winter wheat that can practically destroy an entire crop of a susceptible cultivar (Figure 1). In Illinois, the widespread use of resistant or tolerant cultivars has kept losses from this disease to a minimum in recent years.

VIRUS

Soilborne wheat mosaic virus particles (called virions) are rigid hollow rods 20 nanometers (nm) wide of two principal lengths, 90 to 160 nm and 300 nm. (Virus particles can only be seen with an electron microscope). Particles of both sizes are necessary for infection. The virus is highly variable and the length of the predominant short rods often changes as the wheat plants grow. Symptoms change as the predominant rod length changes, but the relation of rod length to yield loss is unknown. Infected cells often contain amorphous and crystalline inclusion bodies that contain virions in a paracrystalline array.The virus also infects certain cultivars of fall-sown rye, barley, emmer, and spelt, wild annual bromegrass (*Bromus commutatus*), sorghum, and some species of *Chenopodium* have been inoculated experimentally. Spring-sown wheats and most wild grasses appear to escape infection. The virus can remain infectious in dried leaves for several years or more. It is not transmitted through the seed or by insects, but it is transmitted by a soil-inhabiting fungus or mechanically at low rates

Symptoms

Two types of symptoms have been reported, chlorotic leaf mottling or mosaic and rosetting or stunting. Plants infected with the soilborne wheat mosaic virus usually appear in early spring as irregular patches of light green to bronze-yellow or light purple wheat within a field – depending on the cultivar, strain of the virus, and seasonal growing conditions. Severely diseased fields have an uneven appearance. The

size and shape of infested areas will vary. The disease often occurs in poorly drained low areas and waterways in fields. A mosaic-infected area does not increase in size during the growing season. The infected area may increase over time due to tillage, land leveling, or flooding of fields. Wheat in the diseased area may be moderately to severely stunted in the early spring, but may recover later (Figure 2). Under conditions unfavorable for growth, however, infected plants remain dwarfed to maturity. Roots may be more severely stunted than shoots in some cultivars. Some plants may die, while others will produce fewer stems (culms) and heads. Maturity is often delayed. The heads on diseased plants may be shorter than normal heads and have shriveled, lightweight kernels.

Figure 2. Area in wheat field of highly susceptible cultivar infected with soilborne wheat mosaic virus.

The severity of this disease varies greatly, depending on the resistance of the wheat cultivar, concentration and virulence of the virus strain(s) in the soil, weather conditions, and planting date. A prolonged, cool growing period with a mean temperature below 60°F (16°C) appears necessary before susceptible wheat cultivars are appreciably damaged by this disease.

Soilborne wheat mosaic is sometimes mistaken for winter injury, wet spots in fields, an uneven distribution of fertilizers, or a nutrient deficiency. Field ice becomes a problem when wheat yellow mosaic is in the area.

ROSETTING

A few strains of the virus cause rosetting in highly susceptible wheat cultivars. The leaves and tillers remain short, growth is bunchy or compact, and tillering is excessive (Figure 3). The leaves of such plants are usually bluish green and may retain this color throughout the growing season. At other times, rosetted plants die early without developing much green color. Leaf mottling is usually not as pronounced in rosetted plants.

Figure 3. Rosette stage of soilborne wheat mosaic, foreground; wheat plants not infected, background.

LEAF MOTTLING

Soilborne wheat mosaic is best identified by an irregular mottling, streaking, and blotching of the leaves when plants are growing rapidly in very early spring before heading. The color of the mottling varies from a hard-to-see pale green to a conspicuous lemon yellow that may involve most of the leaf blade as well as the leaf sheaths and glumes. The mottling may persist into late spring as long as the leaves are green – especially if the temperatures remain abnormally cool. When temperatures are above 64°F (18°C), new growth is symptom-free except for stunting. No yield loss occurs on resistant cultivars.

Disease Cycle

The virus causing soilborne wheat mosaic survives in the soil and crop residues from season to season protected by its fungal vector or agent, *Polymyxa graminis*, an obligate parasite in the roots of many grasses and a few higher plants. During cool wet periods motile spores (zoospores) are released by the fungus and infect roots of wheat plants. The virus particles are either inside the spores of the fungus (both zoospores and thick-walled resting spores) or tightly bound to the surface of these spores. The fungus normally infects wheat roots shortly after planting in the fall. The symptoms, however, do not normally appear until early spring.

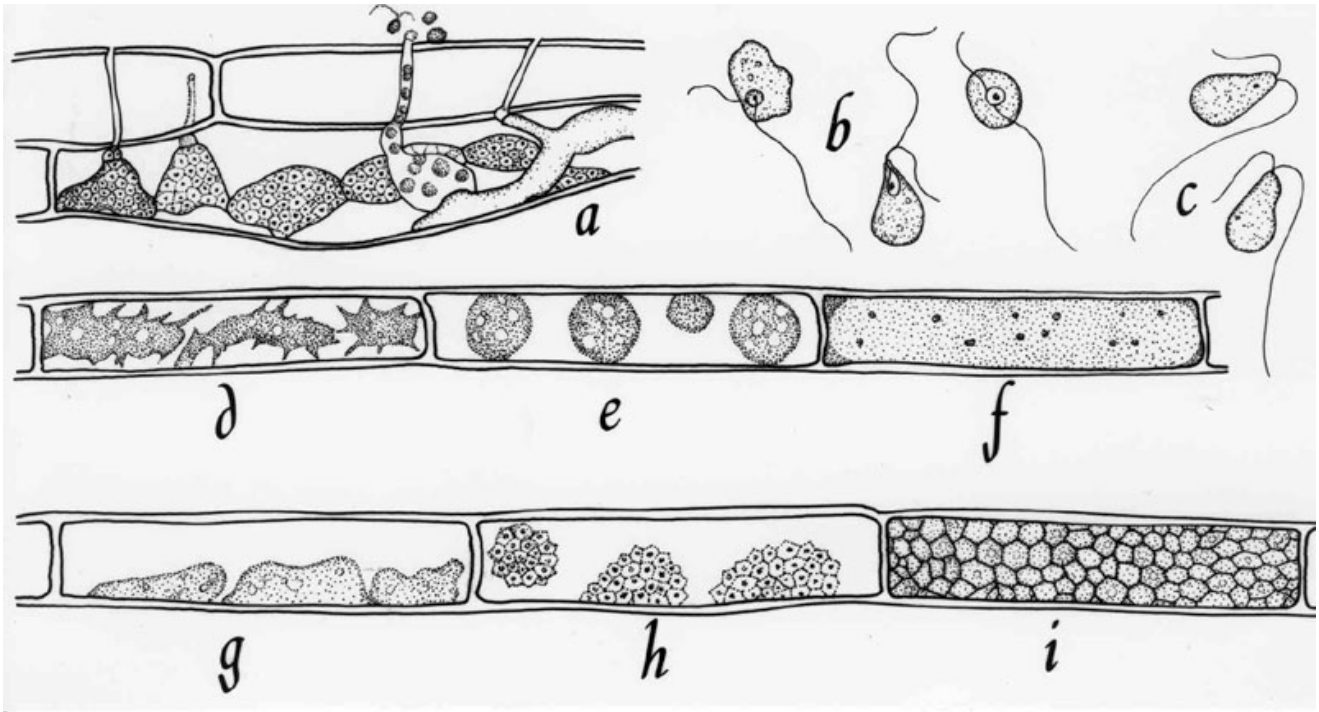

Figure 4. Life cycle of Polymyxa graminis: (a) mature sporangia with exit tubes passing through cells. Motile zoospores emerging formed from one sporangium; (b) biflagellate zoospores; (c) living amoeboid zoospores; (d) amoeboid spores during period of active growth; (e) individual plasmodia (meronts); (f) same cell as d after the plasmodia have coalesced; (g) plasmodia just prior to cleavage into incipient cysotsori; (h) cleavage of plasmodia into polygonal resting spores (cystosori); (I) wheat cell completely filled with resting spores (Adapted from ledingham).

The virus is transmitted from plant to plant by its fungal vector. The zoospores are produced in virus-infected roots or debris and carry the virus. The zoospores swim through the soil solution to healthy root hairs and epidermal cells, penetrate them, and thus inoculate the plant. Once inside the plant, *P. graminis* replaces plant cell contents with plasmodial bodies that either segment into additional zoospores or develop into resting spores two to four weeks after infection.

The *Polymyxa* fungus survives unfavorable periods in the form of resting spores clustered in the cortical and epidermal cells within plant debris (Figure 4). These spores can survive in soil for 10 years or more in the absence of wheat or other host plants. The virus and its transmitting fungus are capable of spreading with any movement of infested soil, even wind-blown dust. Because the swimming zoospores of the fungus transmit the virus, soilborne wheat mosaic is most common and severe in low, wet areas of fields in years when fall rainfall is ample.

WHEAT YELLOW MOSAIC (WHEAT SPINDLE STREAK MOSAIC)

Wheat yellow mosaic (usually called wheat spindle streak mosaic) is caused by a soilborne virus which also is transmitted by the soilborne fungus, *Polymyxa graminis*. The virus can survive for 10 years or more in soil in close association with the fungus. Wheat yellow mosaic apparently makes plants resistant to soilborne mosaic virus. The ratio of soilborne wheat mosaic virus to wheat yellow mosaic virus in plants infected with both viruses is about 20:1.

Wheat yellow mosaic was first described in Japan in the early 1960's. At about the same time, the same disease was reported from the eastern United States-Canada border and described as wheat spindle streak mosaic (Ontario soilborne wheat mosaic in Canada). Wheat spindle streak mosaic is now considered to be wheat yellow mosaic virus.

In North America, wheat yellow mosaic is most prevalent near the Great Lakes but occurs over much of southern Ontario and the east-central United States. The disease is found in Illinois in the general area where soilborne wheat mosaic is prevalent. In southwestern Ontario, yield losses occur each year and may reach 40 percent in some fields where very susceptible cultivars are grown. The disease is now known to occur in China, France, Germany, and India.

The only host for wheat yellow mosaic is wheat, except in Germany, where it has been reported on barley and rye. Like soilborne wheat mosaic, both winter and spring wheats are susceptible to the virus but spring wheats rarely develop symptoms.

VIRUS

Wheat yellow mosaic virus particles are slightly narrower and much longer than those of soilborne wheat mosaic, being 14 to 18 nm wide and normally 200 to 2,000 nm long. The infectious flexuous rods are about 600 nm long and apparently aggregate to form particles up to three microns long. These particles are sparse in host cells of wheat and are difficult to observe in leaf-dip preparations in the electron microscope. They are found scattered and in loose to tight bundles in most epidermal and parenchyma tissues in leaves showing symptoms of wheat yellow mosaic. Infected host cells also contain prominent inclusion bodies which appear as pinwheels and membrane proliferations.

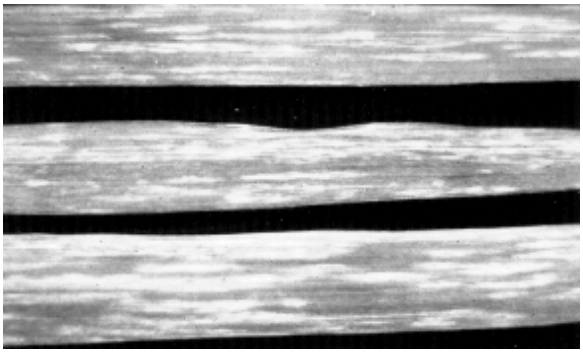

Figure 5. Leaves infected with wheat yellow mosaic. Note streaks and "spindles" parallel with the leaf veins. (Courtesy R. E. Stuckey)

Symptoms

The first leaves produced in early spring develop yellow-green mottling, dashes, and streaks. The discontinuous streaks are oriented parallel with the leaf veins and taper at each end to form yellowish "spindles" (Figure 5). Symptoms are most prominent on the lower leaves because warmer spring temperatures present their development on younger leaves. As the leaves mature and when temperatures remain cool, the center of the spindle may turn brown, streaking may progress to the flag leaf, and the yellow-green areas tend to merge. Reddish streaking and dieback of leaf tips or entire leaves sometimes

occurs. Infected wheat plants remain slightly stunted and produce fewer tillers than healthy plants. When warm weather arrives, new symptomless leaves hide the lower leaves showing symptoms. Fewer heads and kernels are produced on infected plants, but kernel weight is not appreciably affected. Cold hardiness is reduced by infection with the virus. The disease tends to be more uniformly distributed throughout fields than soilborne wheat mosaic.

Disease Cycle

There are several similarities between wheat yellow mosaic virus and soilborne wheat mosaic virus. Both viruses are transmitted in nature by the same soilborne fungus, *Polymyxa graminis*. The two viruses also survive in soil for years in the absence of wheat, apparently in a stable, close association with their fungal vector. Fall infections are most important and account for symptoms produced in early spring. Spring infections may occur but cause no reduction in yield. The two viruses and their vector also are spread by any agency that relocates infested soil.

Infections of wheat yellow mosaic do not occur above 68°F or 20°C, and disease development is checked above 64°F (18°C). The optimal temperature for symptom development is between 41° and 57°F (5° to 13°C). The optimum temperature for virus transmission in the soil is 59°F (15°C). Without prolonged cool temperatures in spring, wheat yellow mosaic is of little importance in Illinois.

Control

1. The planting of highly resistant or tolerant cultivars offers the only practical method of control for both diseases. Some wheats are resistant to one or both viruses, others to the *Polymyxa* vector. Most of the soft red winter wheat cultivars recommended for growing in Illinois, as well as a number of hard red winter wheats, are resistant to common strains of the soilborne wheat mosaic virus. Only a few of the cultivars presently recommended are resistant to wheat yellow mosaic (spindle streak mosaic). A listing of cultivars resistant to these two diseases is given in the Illinois Pest Control Handbook which is updated annually and available at your nearest Cooperative Extension office. There are no known commercial wheat cultivars that are immune to either virus.

2. Late autumn planting, after the Hessian-fly free date, is strongly suggested to reduce losses to these and other wheat diseases. Continuous wheat culture should be avoided.

3. Mosaic-susceptible cultivars may be grown in soil where soilborne wheat mosaic and wheat yellow mosaic viruses with their fungal vector do not occur.

4. Liberal use of fertilizers, based on a soil test, tends to decrease the incidence of these diseases.

   Since the two viruses and the fungus that transmits them persist in the soil and crop debris for 10 years or more, crop rotation is of little value in control.