Wheat Streak Mosaic of Wheat

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Wheat streak mosaic disease caused by *Wheat streak mosaic virus* (WSMV) is an economically important disease of wheat in the Great Plains. This virus is especially problematic in the Great Plains mainly due to the availability of native grasses which serve as good hosts for the virus as well as the vector, the wheat curl mite (WCM). First reported in Nebraska in 1922, WSMV is now widely spread throughout the wheat-producing areas in the United States. In South Dakota, WSMV can cause significant yield losses especially when infections occur in the fall. The disease is mostly damaging when large portions of wheat fields are infected by the virus (Figure 1) in fall. Yield losses vary from negligible to total loss where producers either replant with a different crop in the spring or are unable to harvest the wheat because of stunted wheat that cannot be picked by the combine. Winter wheat is more impacted by WSMV than spring wheat because of a longer infection period when virus infections take place in the fall. The disease can also occur in barley, corn, rye, oat and several annual and perennial grasses.

Figure 1. A winter wheat field with severe wheat streak mosaic infection in Tripp County.

Symptoms

Although virus infections can occur in the fall, symptoms are mostly obvious in spring when temperatures begin to warm-up and when wheat is jointing. In severe infections, WSMV symptoms start from the field edge (adjacent to the source of the inoculum) and become less evident as one moves away from the field edge (Figure 1). In low virus infection cases, a few and random plants get infected and may be scattered throughout the field. Infected plants show yellow streaking or mosaic patterns on young leaves (Figure 2). Depending on the time of infection and the cultivar, infected plants may be stunted with fewer tillers that tend to prostrate. Symptoms worsen with stress caused by dry and hot conditions. The oldest leaves tend to have severe symptoms and may die prematurely. Wheat heads, if formed, are totally or partially sterile and usually will not be picked by the combine during harvesting.

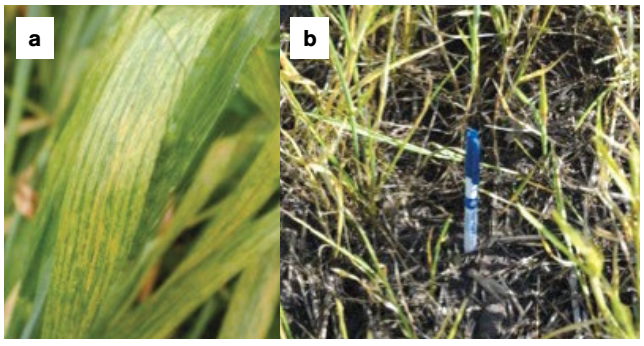

Figure 2. (a) Wheat streak mosaic virus symptoms on leaves. Notice the streaks of green and chlorotic areas on the leaf. (b) Wheat plants with severe wheat streak mosaic virus symptoms. Notice the thin stand with poor tillering.

Heavy feeding of wheat curl mites cause wheat leaves to curl inwards around the mid-rib hence the name wheat curl mites (WCM). Such plants have the newly developed leaf trapped in the rolled leaf forming a loop (Figure 3). However, absence of rolled leaves may not mean absence of WCM and sometimes presence of WCM may not necessarily mean presence of WSMV. The WCM also transmits two other viruses: *Wheat mosaic virus* and *Triticum mosaic virus*. These two viruses have only been recently found in South Dakota and at low incidences. Research shows that the three viruses can occur together in the same plant, and in such instances yield losses are far greater than when only one virus is infecting the plants.

Figure 3. Leaf trapping where the newly developed leaf fail to unfold due to heavy feeding of wheat curl mites (Photo credit: Gary Hein).

Disease cycle of wheat streak mosaic

Wheat streak mosaic virus is transmitted primarily through the vector, the wheat curl mite (WCM, *Aceria tosichella*). WCMs are microscopic (0.3 mm long) and can be seen using a 20x hand lens (Figure 4). When temperature and natural enemies are not limiting, mites develop from egg to adult in eight to 10 days, and can increase to a high population density in a short period. WCMs are capable of crawling over short distances between tillers/or leaves that are in contact with each other. Dispersion from plant to plant occurs by the wind, and is the reason why heavy WSMV infections are found along the field edges first. Only younger stages of WCMs (nymphs) acquire the virus when they feed on infected plants; the virus is not passed to the next generation. When WCM acquire the virus, they can remain infective for seven to nine days before losing the infectivity and hence requiring to feed again on an infected plant to become infectious.

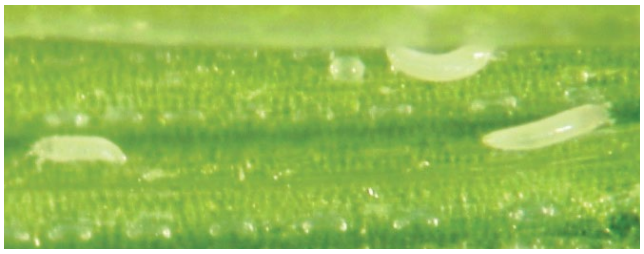

Figure 4. Wheat curl mites under magnification (Photo credit: Gary Hein).

Research in Australia indicated that WSMV can be seed-transmitted but the rate of transmission was found to be less than 2%. However, no seed transmission has been reported in the United States, indicating that transmission by WCM remains the main risk factor for WSMV.

Wheat streak mosaic cycle starts in the fall with virus infections coming from volunteer wheat or grass weeds (Figure 5). When the condition of the WCM hosts begin to deteriorate, mites crawl to the leaf tips or leaf surface where they are exposed to the wind. They are then blown away and deposited on any plants as the wind subsides. Unlike other insect vectors which choose which host to land on, WCM land whenever and wherever the prevailing wind deposits them. If the WCM happen to land on emerging wheat in the fall or other suitable hosts, the mites will crawl into the leaf whorls where they feed and in the process transmit WSMV. WCM will remain on wheat throughout the spring and part of the summer. Wheat curl mites will continue to crawl to new leaves until head emergence. WCM will then move to the wheat head which has many feeding sites and offers protection from harsh weather. As the wheat head begins to ripen, WCMs position themselves at the edge of the spikelet surface where they are picked-up by the wind.

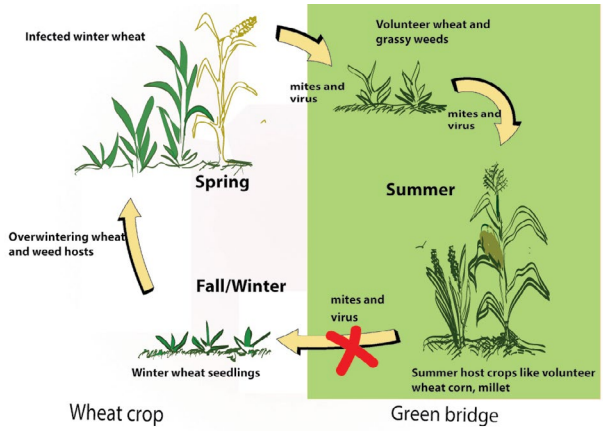

Figure 5. Lifecycle of *Wheat streak mosaic virus* (adapted from M. McMullen, NDSU).

Risk factors for Wheat streak mosaic

Since the virus survives only in living tissues and the WCM must feed on infected plants to acquire the virus, the main risk factor for wheat streak mosaic outbreaks is the presence of over-summering hosts (volunteer wheat, grass weeds) that ensure the survival of both the virus and the WCMs (Figure 5). The over-summering hosts are also known as the "green bridge" between the summer wheat after harvest and the fall sown wheat (Figures 5 and 6). If wheat is planted early, direct movement of the mites from recently harvested wheat field can occur. Hail events which lead to grain shattering may lead to early volunteer wheat which is likely to become infected with WSMV and will be the source of WCMs and virus for the fall sown wheat (Figure 7).

Figure 6. Volunteer wheat and grass weeds in a fallow field. This will become a source of wheat streak virus inoculum for wheat planted into this field or nearby fields.

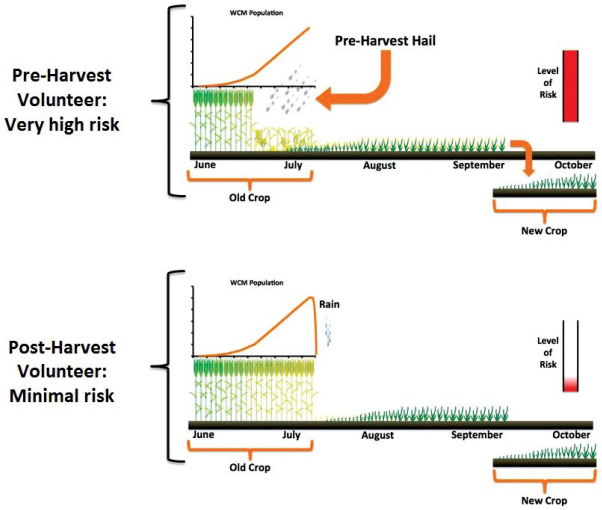

Figure 7. Risk of *Wheat streak mosaic virus* increases with hail events and volunteer wheat (Justin McMechan, UNL).

Another risk factor for wheat streak mosaic is the time of planting and fall temperatures. If planting is done early to mid-August and there is an extended mild weather in October-November, chances increase for WSMV infections to take place. Once WCMs have established on wheat in the fall, they will survive winter as eggs, nymphs or adults protected inside the leaf whorls near the crown. WCMs can survive harsh winter conditions. As wheat greens up the following spring, WCMs become active and multiply. Overcrowding of WCM on leaves is thought to be one of the factor which leads to WCM dispersal in spring and this can lead to new infections stemming from fall infections. However the spring infections do not cause as heavy yield losses as fall infections.

Management of Wheat Streak Mosaic

Wheat streak mosaic virus and other viruses transmitted by WCMs are best managed through cultural practices. Unlike fungal diseases, nothing can be sprayed on virus-infected plants to prevent or cure virus infection. However, several practices can be used to prevent or lessen chances of wheat getting infected by WSMV.

- Control volunteer wheat and grass weeds before planting in the fall. Volunteer wheat and grass weeds are the most important risk factor for the wheat streak mosaic disease. Volunteer wheat and grass weeds should be destroyed at least two weeks before planting. This period ensures that these hosts are completely desiccated hence eliminating WCM. If an area is known to have WSMV outbreaks, control of volunteer wheat and grass weeds would require a communal effort because WCMs can be blown from neighboring fields up to two miles. Volunteer wheat and grass weeds can be destroyed through tillage or herbicide application.

- Delay winter wheat planting in areas with known high WSMV outbreaks. Planting early in the fall especially when temperatures are mild increases the risk of WCMs landing and transmitting viruses in emerging winter wheat. Delayed planting also ensures that summer crops will have matured and dried down hence reducing chances of WCMs moving from these crops to newly planted winter wheat

- Plant wheat varieties that are resistant/tolerant to WSMV. The virology program at SDSU does virus screening for most public wheat lines and results from this program shows consistent differences between wheat cultivars in terms of grain yield,

reduced symptom severity and extent of virus replication in a cultivar (Figure 8).

- The wheat curl mites can survive on other cereal crops like corn, millet, barley and sorghum. Therefore areas with frequent WSMV epidemics, planting non-host broadleaf crops like field peas, lentils, sunflowers, etc. will help keep WSMV pressure low.

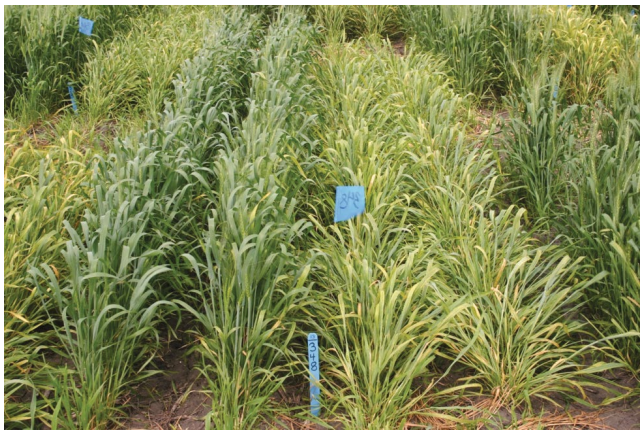

Figure 8. *Wheat streak mosaic virus* screening nursery. Some cultivars are resistant/tolerant to WSMV (Photo credit: Marie Langham).

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