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More than 20 viral diseases are reported to attack barley, but fortunately only a few are of significant concern to barley producers in the Northwest. This publication addresses three of the most common viral diseases of barley: barley yellow dwarf, barley stripe mosaic, and barley yellow streak mosaic.

Barley Yellow Dwarf

Barley yellow dwarf (BYD) has been recognized as a viral disease of cereals and grasses since 1951 and is perhaps the world's most widespread and economically important viral disease of cereals. It is caused by the barley yellow dwarf virus (BYDV).

BYDV is a complex, aphid-transmitted virus that is beginning to be viewed as a group of closely related viruses. It is not seedborne, nor can it be transmitted through soil, by infected crop debris, or by rubbing sap from an infected plant onto a healthy plant. The virus replicates in infected plants and is restricted to the phloem (the plant's food conducting tissue). Aphids feeding on infected plants can acquire sufficient quantity of the virus to transmit and cause infection in as little as 30 minutes, but more typically this requires 12 to 30 hours. Transmission is accomplished in subsequent feedings of 4 hours or more. Aphids carrying the virus remain infectious throughout their lives, but the virus is not passed to the offspring.

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Symptoms

Infected plants may express symptoms in as few as 7 days, or if infection occurs in the fall on winter cereals, symptoms may not appear until the plant resumes growth the following spring.

The principal symptoms of BYD in barley are stunting and leaf yellowing (chlorosis) (Figure 1). Leaves develop yellow tips, and the yellowing progresses toward the base of the leaf with time. Seedling infections result in the most severe symptoms; plants infected before the four- to five-leaf stage may be severely stunted and may not head. Infections occurring after the boot stage often produce only mild symptoms or no symptoms at all. Root growth may also be severely reduced. Disease distribution reflects aphid distribution; therefore, infected plants often appear in clusters within the field, or they may be concentrated along a field margin and diminish toward its center.

Symptoms of BYD are ambiguous and are often overlooked, mistaken for nutritional disorders such as nitrogen deficiency, or attributed to cold, wet soil conditions. In the field, BYD can be tentatively diagnosed by the presence of aphid vectors at some time before symptom expression, by the occurrence of yellow leaf symptoms, and possibly by the occurrence of stunting, as described earlier. Positive diagnosis must be made in the laboratory using serological procedures and/or in the greenhouse by recovery and transmission of the virus by aphids.

Vectors

More than 20 aphid species transmit BYDV. Five of these commonly occur on cereals in the Pacific Northwest, but their abundance varies from area to area and from year to year. The five aphid vectors of BYDV are bird-cherry oat aphid, corn leaf aphid, English grain aphid, greenbug, and rose grass aphid. The Russian wheat aphid does not transmit BYDV in the United States.

Hosts

BYDV has a wide range of hosts within the grass family. In addition to wheat, barley, and oats, it infects many perennials as well as annuals. Among them are widely distributed lawn,
pasture, and range grasses such as Kentucky bluegrass, wild barley, wild oats, goatgrass, ryegrass, fescues, and cheatgrass (downybrome). Some are symptomless carriers of the virus while others exhibit characteristic symptoms.

Corn is an important symptomless host in the Pacific Northwest. In a survey of field and sweet corn fields conducted across southern Idaho in 1981, the incidence of infected plants in individual fields ranged from 0 to 55 percent, and all plants were symptomless. Since BYDV is not transmitted in the seed and does not occur in the soil or in plant debris, host plants that remain alive over winter provide an important means of virus survival and disease spread the following year.

The relative importance of specific hosts in the development of an epidemic is not well understood and is complicated by the particular preference of the various aphid vectors for certain plant species. In addition, there are at least five strains of BYDV, most of which are transmitted specifically by only one or two aphid species. All five strains have been detected in southern Idaho, and four of the five strains are known to occur in Montana. The vector non-specific PAV strain predominates in Oregon and Washington.

**Effects on Grain Yield and Quality**

The effects of BYDV infection on grain yield and quality vary considerably. They depend on variety, water status, crop growth stage when plants become infected, and possibly the strain of BYDV involved. In general, plants infected in the seedling stage yield less than those infected in later stages of growth. Since BYDV infections may cause a smaller root system, plants grown under dryland conditions are usually more severely affected than those grown under irrigated conditions. BYD epidemics in spring barley are infrequent, but when spring planting is delayed, losses can be severe. Grain from severely diseased fields can be shriveled and have low test weight.

**Control**

When they become available, resistant varieties will offer the best method of BYD control. The seeding of all varieties of cereal grains should be timed so that the more susceptible seedling stage occurs before or after the period when aphids are active. Thus, late fall or early spring seedings are less likely to result in significant yield losses.

In situations when growers cannot seed during the recommended times, especially when they must plant earlier in the fall, growers should use Gauch® seed treatment insecticide for barley and wheat, or granular systemic insecticides applied in-furrow at planting time. The use of systemic insecticides in spring-planted cereals has questionable value,
but when planting is delayed, insecticides offer the only hope for reducing potential BYD losses.

None of our currently recommended barley varieties in Idaho and Montana are resistant to BYD. Sources of resistant or tolerant germplasm have been identified and are being incorporated into commercial varieties. In addition to traditional breeding methods, new technologies developed through genetic engineering show promise for developing BYD-resistant varieties.

When possible, growers should minimize or eliminate other stresses, such as nutrient and/or moisture deficiencies. Supplying adequate nitrogen according to a soil test reduces BYD symptom severity in fields where nitrogen is deficient; however, adding nitrogen to a well fertilized field will not decrease BYD symptoms. Additional irrigations may be needed because infected plants may have stunted root systems. Controlling aphids feeding in the heads reduces crop losses and will help to minimize overall stress on the infected crop.

Plowing under a BYDV-infected crop is seldom recommended unless the crop is severely diseased and is on dryland. If other serious yield-limiting factors are also present, such a measure may be considered.

**Barley Stripe Mosaic**

Barley stripe mosaic (BSM) has been recognized as a disease of barley since 1910, although barley stripe mosaic virus (BSMV) was not shown to be the causal agent until 1951. The disease was originally named false stripe to differentiate the problem from a common fungal disease called barley stripe.

BSM is primarily a seed borne disease. The viral pathogen reaches the seed by infected pollen or ovules. It is not spread by insects or mites, but it can occasionally be transmitted from plant to plant by mechanical means, such as leaf rubbing. Research in California suggests that plant to plant mechanical spread is more prevalent than pollen transmission. Research in Montana has shown the virus can spread to adjacent rows spaced 12 inches apart by this method.

**Symptoms**

The symptoms of BSM vary widely depending upon viral strain, host variety, and weather conditions. Infected leaves...
exhibit a white to yellow mottle or streaking with brown stripes appearing in a v-shaped or chevron pattern (Figure 2). Leaves in infected plants may turn nearly white. Plants arising from infected seed or those infected mechanically early in the growing season are also stunted.

Infections are less noticeable on young plants. Early leaf symptoms include a yellow mottle that may be mistaken for environmental stress. As the plants mature, the symptoms become more distinct. At maturity, additional symptoms of BSM infections include empty or sterile florets, poorly developed heads, and immature kernels. Infections by mild strains of BSM often go unnoticed but can still cause yield losses.

On occasion, increased susceptibility to ergot has been observed in BSM infected barley. The increased susceptibility resulted from partial male sterility induced by the infection.

BSM symptoms develop best at temperatures of 71 to 86 degrees F. At lower temperatures, symptoms are less pronounced, and the rate of systemic spread is reduced.

Hosts

Unlike barley yellow dwarf, BSM has a relatively narrow host range. It is primarily a disease of barley, but it also occurs in wheat and wild oats. However, BSM apparently does not have a serious effect on wild oats or wheat. Furthermore, BSM isolates from wild oats do not infect barley, and barley isolates do not infect wild oats. Wheat and barley isolates, however, may infect both wheat and barley.

Effects on Grain Yield and Quality

Losses due to BSM are relatively small compared to those caused by barley yellow dwarf and several other barley diseases. However, the dollar value of losses may be great if a high percentage of seeds of a popular variety are infected. For example, during the 1950s and 1960s, over 50 percent of Montana’s barley acreage was seeded with varieties Compana and Unitan. With 50 percent of the seed lots carrying BSM, an average yield loss of 4 bu/acre resulted. Montana suffered its peak economic loss due to BSM, a loss of $3.1 million, during the 1964 growing season.

Control

The best method of controlling BSM is planting virus free seed. Currently, North Dakota and Montana seed laboratories conduct virus inspections using sensitive serological tests such as ELISA. Prior to 1993, all barley in the certified, registered, or foundation categories in Montana was tested, and there was a zero tolerance for BSM. In 1993, the law was amended so that only foundation and registered classes had to be tested. The cost of a BSM test at Montana State University is currently $52.50.
BSM is considered a “breeders’ disease.” This means that during varietal development, barley breeders can eliminate the virus by testing their early generation seed and discarding all infected lots. Most barley breeding programs, including those in Montana and Idaho, are screening their materials for the presence of BSM. Additionally, scientists at North Dakota State University screen the world barley collection for this virus.

The development of varietal resistance to BSM has had limited success due, in part, to the wide variation in virus strains that occurs in nature. Although the technology now exists to ensure that new varietal releases are free of BSM, numerous existing and old seed lots still harbor the virus. For example, in the early to mid 1980s, nearly 40 percent of the Klages seed lots from Idaho were infected. Although this problem is greatly reduced today, producers still using some of the older varieties are encouraged to have their seed lots tested for the presence of BSM.

Barley Yellow Streak Mosaic

Barley yellow streak mosaic (BaYSM) is a new disease of barley, which was first described in 1988. The disease was initially brought to the attention of scientists in 1982 when a single barley field in Pondera County, Montana exhibited previously undescribed symptoms (Figure 3). During the period between 1983 and 1987, the disease reached epidemic proportions in Pondera and four other contiguous counties. By 1988, virologists at Montana State University had determined that barley yellow streak mosaic virus (BaYSMV) was the causal agent and that the brown wheat mite carried the virus. Since 1988, the disease has spread throughout the triangle of north central Montana (Figure 3) and has recently been confirmed in Bighorn County in south central Montana.
BaYSM was confirmed in Oneida County, Idaho in 1991, making Idaho the second state in the United States to report it. During the 1992 season, a survey of the Pocatello Valley in Oneida County revealed a high level of plants infected with BaYSM. The disease was also confirmed in nearby Caribou County that year. BaYSMV cannot be transmitted by seed, soil, infested crop debris, or rubbing sap from an infected plant onto a healthy plant.

**Symptoms**

As the name suggests, BaYSM is characterized by yellowish to white streaks on the leaf blade that run parallel to the leaf veins. Early symptoms may appear as “washed out” light green leaves progressing to light green stripes or streaks. As the severity of the infection increases, the more characteristic yellow to white streaks appear (Figure 4). In extreme cases, brown streaks appear, and the plants may die. Moderate to severe stunting accompanies BaYSMV infections.

A diagnostically unique symptom of BaYSM is the development of streaks or stripes on only one half of the leaf, parallel to the mid vein. The other side of the leaf may appear normal.

The first symptoms within an infected field appear in water-stressed areas, such as sandy spots and ridge or hill tops, because the mite vector feeds preferentially on plants under stress. Infected areas appear drought stressed, pale green to grey, and unthrifty. Warm, dry weather favors mite development and spread of BaYSM. Conversely, sprinkler-irrigated crops or crops produced during an abnormally wet season are unfavorable for mite development, so these conditions should cause disease incidence and severity to be low.

**Vector and Virus Characteristics**

Initial studies with known virus vectors such as aphids, leafhoppers, and thrips showed that none were capable of transmitting BaYSMV. At present, however, the brown wheat mite, *Petrobia latens*, is the only known vector of the virus. Barley is the preferred host of the mite, but it has been reported as an occasional direct pest of wheat since the early 1950s. The brown wheat mite is generally considered a minor pest in the low rainfall, hard red winter wheat production areas of the United States. In the higher rainfall areas or with sprinkler irrigation, the mite is not considered a problem. Prior to 1988, it was not known to carry and transmit any cereal viruses.
Hosts

BaYSM was first found in barley, and so it was given the name barley yellow streak mosaic. However, the pathogen also attacks other cereal grains including winter and spring wheat. Damage to wheat is not as severe as it is in barley, perhaps because wheat is a poor host for the mite.

Effects on Grain Yield and Quality

Definitive tests on losses in yield and quality have not been completed. Reports from growers who have harvested affected and unaffected portions of fields indicate that yield losses approach 30 bu/acre or 40 percent. These loss figures may be excessively high since the disease is more pronounced in areas of affected fields that are stressed for moisture. However, in some severely diseased fields in Idaho, a combination of the virus infection and drought rendered the crop unharvestable. In the most severely damaged fields, up to 90 percent of the plants were symptomatic. Producers also report a reduction in test weight and kernel plumpness associated with BaYSM outbreaks.

Control

Several factors are known to contribute to outbreaks of BaYSM. These include barley monoculture, late spring seeding, moisture stress, warm temperatures, and high levels of barley straw. The debris from previous barley crops apparently favors winter survival of the brown wheat mite. Currently, the best control measures include crop rotation, mowing, and early spring seeding. Irrigation, or heavy rainfall, will also significantly reduce mite populations.

Control of the mite with insecticides generally is not useful. In dryland situations, commonly available foliar insecticides, such as Di-Syston and Dimethoate, do not provide economically acceptable control of the mite or subsequent suppression of the virus. In-furrow application of Di-Syston 15G at seeding significantly reduced early mite populations but was not economically advantageous. In irrigated barley, where the plants need to be protected from emergence to the first irrigation, the granular application may prove economically viable.

Presently, no commercially available, locally adapted barley varieties exhibit resistance to BaYSM. However, of the 1000 genotypes within the barley core collection screened for resistance to BaYSMV, only two lines, Haua and Skinless, exhibited some tolerance to the disease. These sources were crossed with Harrington, Morex, Hector, Steptoe, and Klages in an attempt to incorporate this tolerance into locally adapted lines. Unfortunately, none of the resultant crosses demonstrated a useable level of tolerance, so work with these crosses was terminated.

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