



BARLEY YELLOW DWARF VIRUS DISEASE OF SMALL GRAINS

The barley yellow dwarf virus (BYDV) is spread by aphids and induces probably the most widely distributed and most destructive virus disease in the world. Besides small grains, many wild and cultivated grasses are susceptible, although many of its hosts remain symptomless. Before 1951, the cause was attributed to nutrient deficiencies and other factors. The name describes the characteristic symptoms produced by the virus on susceptible barley. The oat diseases formerly called "red leaf" and "gray spot" are now known to be the same disease and are also caused by the BYD virus.

In 1959 this virus, together with greenbug feeding, caused an estimated loss of 34 1/2 million bushels of oats, amounting to \$24.3 million and represent 28% of the total oat production in Illinois. Severely infected crops often yield no grain (Figure 1). Over large production areas, BYD typically reduces yields by 5% to 25%

Damage to small grains varies with the cultivar, virus strain, time of infection, and environmental conditions. The severity of BYDV damage depends on plant response. Seedling infection is most severe. Late-planted spring oats and oats growing in poor soils are damaged more severely than those planted early in good soil. Oats following soybeans are less affected than those following corn where no fertilizers have been applied.



Figure 1. Various stages of yellow dwarf on barley. Test plots at the University of Illinois.

Research work to develop well-adapted, highly tolerant oat and wheat varieties is being conducted at the University of Illinois cooperatively with the Agronomy and Plant Pathology Departments and the U.S. Department of Agriculture.

Yellow dwarf first appears early in the season, usually along the margins of small-grain fields, and later develops within a field in more or less circular spots up to 30 feet or more in diameter. As the season progresses, these diseased areas may enlarge and merge. When aphid populations are high, entire fields may become affected (Figure 1). Distribution of the disease within a field apparently depends on the colonization pattern and preferential feeding of the aphid vectors. For example, the corn leaf aphid (Figure 2) often prefers barley and avoids oats, causing a higher disease incidence in barley. Farmers often fail to associate early aphid infestations with yellow dwarf because symptoms usually do not appear until two or three weeks after feeding. By that time the aphids may be gone. The symptoms of early fall infections are often suppressed until spring. Then the disease can be determined only by virus recovery tests under controlled conditions in the greenhouse and laboratory.

For further information contact your nearest Extension office or an Extension Specialist in the Department of Crop Sciences, University of Illinois at Urbana-Champaign

Symptoms

Symptoms typical of BYDV disease on small grains are often overlooked and may be confused with other causes, e.g., mineral deficiencies, bacterial toxins, leaf breakage, low temperatures, root and crown rots, and others. Definitive diagnosis requires serologic tests such as enzyme-linked immunosorbent assay (ELISA) and/or recovery and transmission of the virus by aphids.

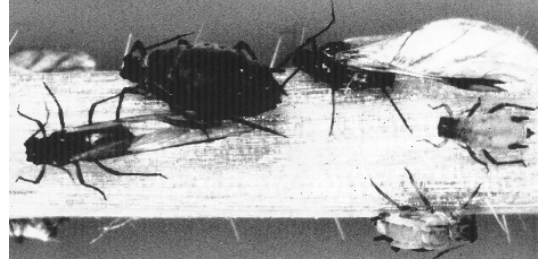


Figure 2. Corn leaf aphids feeding on infected plant (courtesy Dept. Plant Pathology, Cornell University, W.F. Rochow).

The first symptoms on oats, and to a lesser extent on barley and wheat, are the appearance of faint yellowish green blotches, usually near the leaf tip. The blotches enlarge rather rapidly, merge, and turn various shades of red, purple, brown, or yellow-orange. The yellowish green blotches continue to appear on lower parts of the leaf before they change color. Affected portions often die as the infection spreads through the entire plant. The leaves may curl inward, are flexible, and appear more erect than usual. Symptoms generally appear first on the older leaves. Late-infected plants may develop symptoms only on leaves growing actively at the time of infection. Blasting of florets also occurs; it may involve only a few florets or, if severe, plants may fail to head. Kernels may shrivel and test weight may be reduced.



Figure 3. Vermillion wheat dwarfed by BYDV fall infection. Taller rows are healthy

In barley, the most characteristic symptoms are dwarfing and the brilliant yellow coloring of the leaves which extends from the tip towards the base. With late infections only the flag leaf may show symptoms.

In wheat, severe dwarfing and general yellowing are less common (Figure 3), and the disease is more severe when infection takes place in the fall than in the spring. Although fall symptoms may be absent, infection predisposes the plants to winterkilling, and disease is severe when new growth starts the following spring. Yellowed or reddened leaves on otherwise normal plants are often typical of postseedling infections. Some cultivars show stunting but no leaf discoloration. Generally, the earlier the infection, the more severe the disease with the root system damaged as severely as the tops.

Aphids and Transmission of BYDV

Yellow dwarf infection may not be proportional to the extent or duration of the aphid infestation. Infestations are difficult to evaluate because it is usually not possible to differentiate between the activity of aphids as direct pests and as vectors of viruses. The amount of feeding damage depends, for the most part, on the toxicity of the saliva injected during feeding and on the number of insects infesting the crop. The outbreak of the disease, transmitted ONLY by aphids, depends on the efficiency with which a given aphid transmits the virus, the source and strain of the virus, aphid mobility, feeding habits, and the age and susceptibility of plants when infected, plus various climatic factors. The aphid species responsible for the outbreak of disease may not necessarily be the most abundant one. One very active aphid feeding for short periods on a number of different plants is a much more important vector than 100 stationary ones.

More than 20 species of aphids are known to transmit strains of BYDV. Virus strains also differ in vector specificity. The oat bird-cherry aphid (*Rhopalosiphum padi*) is the most efficient vector in Illinois. The BYD virus is also spread by other species infesting small grains and grasses, such as the greenbug (*Schizaphis graminum*), English grain aphid (*Sitobion [Macrosiphon] avenae*) apple grain aphid (*R. insertum*), corn leaf aphid (*R. maidis*), and the rose grass aphid (*Metopolophium dirhodum*).

Virus-free aphids must acquire the barley yellow dwarf virus by feeding on diseased cereal or grass plants for periods as short as 30 minutes (more typically 12 to 48 hours) before they are capable of inoculating healthy plants. The virus does not replicate in the aphids, but once they acquire the virus, aphids are capable of transmitting it after a latent period of 12 hours to four days, for the rest of their lives. All summer forms of aphids transmit the virus equally well. Although some strains of BYDV are transmitted by several aphid species, others are highly specific to particular vectors. The quality of the BYDV protein coat and barriers for virus passage from the aphid gut to its saliva are believed to be involved. Specificity is also influenced by the physiologic and behavioral characteristics of aphids, such as their ability to overwinter and multiply, their feeding and flight habits, and their host preferences.

The Virus

BYDV is the type member of the luteovirus group. Its name is derived from the Latin "luteo" which means yellow and describes the most typical symptom of plants infected with luteoviruses. These viruses are restricted to the phloem or food-conducting tissue in infected plants. An electron microscope is required to visualize the virus particles or virions. They are 25 nanometers (nm) in diameter and icosahedral in shape, although sometimes they are referred to as spherical (Figure 4). The genetic material in each particle is one single-stranded RNA molecule that has a molecular weight of about 2 million daltons. The RNA is encased in a coat of globular proteins of about 25,000 daltons.

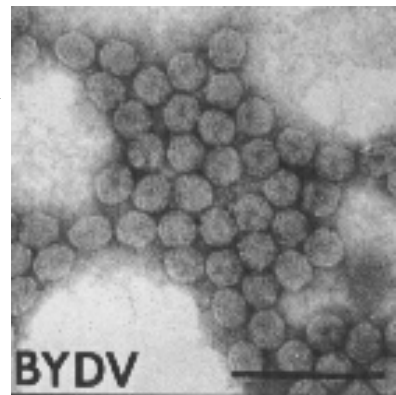


Figure 4. Stained icosahedral particles of BYD virus under electron microscope.

Five strain groups of the BYD virus have been identified that differ according to vector specificity and serologically. These groups can be further subdivided into two subgroups (1 and 2) according to serological, phytopathological, and other biochemical differences.

Disease Cycle

The barley yellow dwarf virus persists in small-grain cereals, in corn, in more than 75 species of perennial and annual grasses, and in its aphid vectors. The spread of BYDV from plant to plant and from field to field depends entirely on aphid movement. In Illinois, winged aphids migrate into small-grain fields in early spring from their alternate hosts and overwintering grass and cereal crops in Illinois or from other states as far south as Texas.

During the growing season, each adult aphid may produce from 10 to 20 young each day. The young aphids mature in a week or two. The daughter aphids, normally wingless, reproduce and usually move only short distances by crawling from plant to plant or by being blown on the wind.

When food is scarce, especially during the spring, winged forms develop that migrate to other small grains and grasses, transmitting the virus to these plants as they feed. Infected cereals and grasses serve as a

virus source for new generations of aphids. In the fall, the aphids migrate to winter hosts – in the process, spreading the virus to fall-seeded small grains. Infected winter barley, wheat, and oats, as well as perennial grasses become important virus reservoirs for spread of the disease in the spring. Eliminating aphids at the virus-reservoir sites, especially along roadsides, fencerows, drainage ditches, wooded areas, wastelands, and permanent pastures, may be a way of preventing the spread of the barley yellow dwarf virus.

BYD epidemics are most common in cool (50° to 66°F, 10° to 18°C), moist seasons that favor growth of small grains and grasses as well as the multiplication and migration of aphids. Aphid flights may be localized or, when aided by wind (including low-level jet winds), may cover many hundreds of miles from south to north in the spring and north to south in the autumn. BYD infections occur throughout the growing season, but are most common and damaging in spring in areas where the aphids overwinter. Inoculated plants become systemically infected and develop symptoms within two weeks at 68°F (20°C), within four weeks at 77°F (25°C), but not at all above 86°F (30°C). The barley yellow dwarf virus is NOT transmitted through eggs, newborn aphids, seed, soil, sap, or other insects.

Control

1. At present, BYDV cannot be fully controlled in the field. Damage in oats as well as in other crops can be greatly reduced by growing tolerant varieties. No major gene(s) for resistance to BYDV have been found in wheat and oats. In barley, the gene Yd_2 confers resistance. Plant breeders, in cooperation with plant pathologists, have developed and are continuing to develop tolerant oat varieties. Winter wheats are also available with moderate resistance. For the latest information on recommended small-grain varieties for Illinois consult the [University of Illinois Agronomy Handbook](#) and [University of Illinois Extension Pest Management Handbook](#). Both publications are revised annually available at your nearest county Extension office.
2. Plant winter wheat, barley, and oats as late as practical, but **after** the Hessian fly-free date. Late summer and early autumn plantings are most subject to severe infection and should be avoided. Late-autumn planting helps winter cereals to escape a buildup of aphids in the fall.
3. Early planting of spring varieties plus proper soil fertilization, based on a soil test, can help to prevent severe damage. Vigorously growing plants are more tolerant of the disease than weaker ones. Large populations of aphids usually do not appear in Illinois until late May. A very early appearance of aphids, such as the one with greenbugs in 1959, is an exception rather than the rule.
4. Where feasible, avoid double-cropping. Volunteer wheat and barley are important reservoirs of the virus.
5. The use of insecticides to control BYDV in small-grain and grass crops is not recommended at present. Contact insecticides act directly on aphids, but have a short residual effect. Upon entering the plant tissues, systemic insecticides act as a poison to the feeding aphids for varying lengths of time. If such an insecticide acts quickly, it may kill the insect before it can inoculate another plant. Some insecticides, however, may even increase aphid mobility and help to spread the virus. The plant from which the insect gets the insecticide does not escape infection. In some cases, though, it may prevent the virus-carrying aphid from inoculating other plants. Unfortunately, this type of insecticide will not keep infection from coming into a treated field from outside. If virus-carrying aphids arrive in steady numbers from beyond the treated area, they can infect the plants on which they land and feed even if these have been treated.