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Barley Yellow Dwarf Virus-Biology and Management

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Barley yellow dwarf (BYD) is a worldwide virus disease of our most important grasses, including wheat, rice and maize. In the mid-1900s, the yellowing symptoms, transmission by aphids, and lack of transmission by rubbing, differentiated BYD from many other plant virus diseases. It served as a model for study of the "yellowing" virus diseases of plants and for elucidation of the mechanisms of circulative virus transmission by aphids. Both, virus and vectors are survived between cropping seasons in volunteer cereals, annual and perennial pasture grasses and wild grasses. Ryegrass is the main reservoir of yellow dwarf viruses. The aphid vectors of the viruses tend to build up in autumn and spring on the grasses, and then move into cereal crops where they often develop colonies. High rainfall areas have a greater build up of the grasses, virus and vectors. Six serotypes i.e. PAV, MAV, RMV for (BYDV) and RPV for (CYDV) of the YDVs which are spread predominantly by different aphid vectors. The distribution and relative importance of the different types are largely dictated by the abundance of the aphid vector species.

Symptoms and Signs

The viruses that cause BYD infect over 150 species of cultivated, lawn, weed, pasture and range grasses. Some infected hosts display no obvious symptoms. However, in many hosts the most common symptom is stunting due to reduced inter-node length. The stunting may be so severe that heads fail to emerge or so mild that it is overlooked unless infected plants are carefully compared with uninfected plants. Root mass of infected plants is also often reduced. The most conspicuous symptom on infected hosts, loss of green color in leaves, is often more prominent on older leaves. Discoloration typically begins 1 to 3 weeks after infection and may be preceded by the development of water-soaked areas on the leaves. Barley leaves often turn bright yellow; oat leaves may become tan, orange, red, or purple; wheat leaves typically turn yellow or red; tips or edges of corn (maize) leaves turn red, purple or yellow and rice leaves typically turn yellow or orange. Symptoms may be affected by the genotype, age and physiological condition of the host plant, as well as by the strain of the virus and the environmental conditions. Other symptoms of infection may include upright and stiff leaves and serrated leaf borders, reduced tillering and flowering, sterility and failure to fill kernels, which results in fewer and smaller kernels and corresponding yield losses.

Pathogen Biology

The viruses that cause BYD are typically 25-28nm in diameter and hexagonal in outline and composed of two proteins (a major coat protein and a minor "read-through" protein) that encapsulate the single-stranded ribonucleic acid genome.

Fig. Typical symptoms of BYD virus disease on wheat plant

This RNA genome serves as a messenger RNA and has five to six genes or open reading frames (ORFs). Some proteins are produced directly from the open reading frame of the genomic RNA, while others are expressed from shorter RNAs, called sub-genomic RNAs. The viruses that cause BYD are restricted to the phloem of host plants, where they are seen via electron microscopy in the cytoplasm, nuclei and vacuoles of infected sieve elements, companion and parenchyma cells(1). Vesicles containing filaments and inclusions containing virus particles are common cytopathological effects of virus infection. The infection and subsequent death of phloem cells inhibits translocation, slows plant growth, and induces loss of chlorophyll, resulting in typical symptoms.

Disease Cycle and Epidemiology

Disease Cycle: The virus particle is deposited in a phloem cell by an aphid vector. The virus replication cycle begins when the single standard RNA is released from the virus which having a positive sense (+ sense) RNA that serves as a messenger RNA. Early gene products (proteins) are translated from the ssRNA. These early gene products are believed to be part of the complex required to make copies of the viral RNA. Complementary/negative sense (-sense) RNA strands are produced from the + sense ssRNA. The - sense RNA strands are then used as templates for the production of many copies of full length + sense RNA. It is believed that these new + sense RNA strands are transported from cell to cell in the host, initiating more replication cycles and thus spreading the infection within the plant. Sub-genomic + sense RNA also made from the - sense RNA strands, and late gene products are expressed from these sub-genomic RNAs. Among the late gene products are the structural proteins of the virus. Full length + sense RNA and structural proteins are assembled into virus, which can be ingested by an aphid vector that transmits the virus to a new cell, in the same or another plant, where the replication cycle can begin again. Newly formed virus particles also spread within the host plant through the phloem, but are not believed to initiate new infections within the plant (2).

Epidemiology: The viruses that cause BYD are transmitted from plant to plant by at least 25 different species of aphids. The viruses cannot be transmitted mechanically and there is no evidence that they multiply in their aphid vectors or are present in new-borne aphids. Thus, all aphids must acquire the viruses by feeding on infected plants. The viruses travel up the aphid's stylet, through the food canal and into the gut, where they are transported into the aphid's hemocoel. The viruses then circulate through the hemocoel to the aphid's accessory salivary gland where they pass into the saliva and can be expelled into the phloem of another plant. The viruses cannot be transmitted by an aphid until they follow this path through the body of the insect, so there are usually several hours after an aphid acquires the viruses during which it cannot yet transmit them. This period of time is called the latent period. Such type of transmission has been called "circulative" because the virus circulates in the body of the insect or "persistent" because the aphid can retain the virus in its body for days or weeks. A single virus-carrying, or viruliferous, aphid can spread the virus to many plants as it moves and feeds. As non-winged aphids crawl and feed on new plants in a field, small patches of infected plants will develop. Winged aphids often develop as host plants begin to deteriorate or when the aphid population is overcrowded (3).

Circulative transmission allows winged aphids to carry the viruses that cause BYD over long distances as they migrate, seeking new hosts. Thus, the sources of infection in a crop may be either local or at a great distance from the affected cereal field or grass pasture. The different viruses that cause BYD are transmitted more efficiently by different species of aphids, a fact that was originally used to distinguish the viruses. For example, BYDV-MAV is efficiently transmitted by the aphid *Sitobion avenae*. The acronym MAV came from *Macrosiphum avenae* virus. Similarly, CYDV-RPV is most efficiently transmitted by the aphid *Rhopalosiphum padi*. These differences in vector transmission are due to the fact that the viruses are selectively transported across the gut and salivary gland membranes of the aphids. For example, some of the viruses that cause BYD will be transported across these membranes in *R. padi*, while others will not. Environmental factors play several roles in the BYD disease cycle. High light intensity and relatively cool temperatures 15-18 ºC generally favor expression of symptoms, such as leaf discoloration which may attract aphid vectors to virus-infected plants. The reproduction rate of subsequent aphid populations is affected by environmental conditions, as is the efficiency with which the aphids transmit the viruses. For example, transmission of the BYDV-RMV by the inefficient vectors *R. padi* and *S. avenae* is dramatically increased at high temperatures (30ºC).

Disease Management: The first step in BYD management is accurate diagnosis of the disease. BYD symptoms may be confused with those caused by other biotic and abiotic factors. Therefore, visual diagnosis is unreliable, and diagnosis by laboratory techniques is required. The diagnostic test most commonly used to confirm infection is a serological test called enzyme-linked immunosorbent assay or ELISA.

Genetic resistance: As for many diseases caused by plant viruses, the most effective control strategies aim to prevent infection of host plants rather than to cure plants that are already infected. The method most widely used to reduce crop losses due to BYD is planting tolerant or resistant cultivars. In tolerant plants, viruses are still able to multiply, but few symptoms are expressed. In resistant plants, the ability of viruses to multiply and/or spread is impaired, resulting in a reduction of disease symptoms. Genes for at least partial tolerance or resistance have been identified in many of the crop plants infected by the viruses. Some plant species also have been genetically engineered to express portions of the viral genome, and some of these transgenic plants display high levels of tolerance to the disease.

Vector management: Another management strategy, which is sometimes feasible, is to reduce the introduction or spread of the causal viruses by aphid vectors. The viruses that cause BYD may be introduced into crops by aphids that migrate at similar times each year. Aphid populations can be monitored by catching the migrating aphids in traps, these aphids can then be tested for the presence of the viruses that cause BYD by ELISA or other assays. When aphid migration patterns are known, it is sometimes possible to alter the planting date so that crops are older and more resistant when the seasonal migrations occur. Another strategy which may be applied when aphid populations are monitored is to reduce the spread of aphid vectors in crops through the use of insecticides. Insecticide treatments may not prevent initial virus infections, but can greatly limit the secondary spread of aphids and, therefore, of viruses. Otherwise use of predators and/or parasites of the aphid vectors as biological control agents are very economic in successfully reduced aphid populations and BYD spread.

References

1. D'Arcy, C. J. and Domier L. L. (2005). Luteoviridae. In Virus Taxonomy: VIIIth Report of the International Committee on Taxonomy of Viruses. eds. M.A. Mayo, J. Maniloff, U. Desselberger, L.A. Ball and Claude M. Fauquet. *Academic Press*. New York.
2. Gray, S. and Gildow F. E. (2003). Luteovirus-aphid interactions. *Annual Review of Phytopathology, 41*, 539-566.
3. Schliephake, E., Habekuss, A., Scholz, M., and Ordon, F. (2013). Barley yellow dwarf virus transmission and feeding behaviour of *Ropalosiphum padi* on *Hordeum bulbosum* clones. *Entomologia Experimentalis et Applicata*, *146*, 347–356.