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Potato Mop-Top Virus: Biology and Disease Management

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Introduction

Potato mop-top is a disease of potato caused by potato mop-top virus (PMTV). It causes dark internal blemishes that negatively impact tuber quality and reduces yields in infected plants. Because it is an emerging disease in the United States, researchers have not published much data about it. Studies at the University of Idaho (UI), other universities, and research institutions (like the United States Department of Agriculture-Agricultural Research Service) are ongoing.

The namesake virus was first described in the United Kingdom in 1966 and has been subsequently found in other areas of Europe, South America, and Asia. The first official find in North America occurred in Canada in 1992 and it was first documented in the United States in 2001 in Maine, from observations in a few lots of processing potatoes originating in Idaho, Oregon, and Washington (although the disease was not considered established at that time). A decade later researchers formally documented it in North Dakota (2011), Washington (2011), Idaho (2012), Colorado (2013), New Mexico (2013), and Oregon (2016).

The Pathogen

PMTV is a virus that belongs to the genus *Pomovirus*, from the family *Virgaviridae*. This genus of viruses contains five species, with molecular and biological properties resembling PMTV.

The vector. PMTV requires a *vector* to move from an infected plant to a healthy one. A vector is an organism that acquires the pathogen from an infected plant and transmits it to another plant. The PMTV vector is a soilborne protozoan, *Spongospora subterranea* f. sp. *subterranea*, also known as *S. subterranea*. This organism by itself is also a potato pathogen that causes the tuber-blemish disease known as powdery scab, as well as associated galls on potato roots. The scabs caused by *S. subterranea* contain

Figure 1. Symptoms of necrotic arcs due to PMTV.

Figure 2. Variations of internal tuber symptoms caused by PMTV.

resting spores which in turn can develop and release flagellated, motile spores. These spores move the virus between plants if sufficient soil moisture is present. The virus can survive in the vector for ten or more years.

It is important to note that while PMTV can occur in the absence of *S. subterranea*, PMTV does not spread from one plant to another within a growing season without the vector's presence.

Symptoms. The most notable symptom caused by PMTV is found within tuber flesh and is characterized by a series of closely spaced dark brown, necrotic arcs or lines (Figure 1). The markings are also known as "spraing" in Europe and it can refer to several other potato-infecting viruses such as *Tobacco rattle virus* or *Alfalfa mosaic virus* that induce similar necrotic lesions within tuber flesh. Internal tuber symptoms can also appear in a less classic form, such as necrotic spots or rings (Figure 2). Such necrotic arcs, lines, or lesions within the tuber negatively impact quality.

External symptoms are often absent, but in some instances large, roughly textured sunken rings, lines, or patches with irregular margins appear on tuber surfaces (Figure 3).

On foliage, in rare cases it causes yellow, chevron-like blotches or patterns on otherwise green leaf tissue (Figure 4). Other viruses that affect potato (such as *Alfalfa mosaic virus*) are associated with similar foliar symptoms known as "calico." PMTV also causes shortened internodes, giving plants a bushy "mop-top" appearance, hence the name PMTV.

Since foliar and tuber symptoms resemble those caused by other viruses, a laboratory test is required to determine the precise cause of the symptoms. The laboratory test can also reveal a coinfection—that is more than one virus infecting a plant.

Though PMTV is vectored by the powdery scab pathogen, powdery scab symptoms are not always present or readily visible on PMTV-infected tubers. The interactions among the powdery scab pathogen, PMTV, potato variety, and the environment are complex. For example, tubers free of powdery scab symptoms might not exhibit PMTV symptoms and vice versa. In addition, powdery scab symptoms may be difficult to see on some varieties, such as Russet potatoes, while symptoms of powdery scab may be more visible on red- or white-skinned potatoes.

Figure 3. External tuber-surface symptoms caused by PMTV.

Figure 4. Foliar symptoms (top image) and stunting (bottom image) can appear in potato plants infected with PMTV.

Disease Cycle

Primary inoculum. At planting, primary inoculum of PMTV can be introduced into a field on seed tubers infected with the virus. If the vector (the powdery scab pathogen) is not present in the soil, then only the mother plant produced by the PMTV-infected seed tuber and a portion (but not necessarily all) of the progeny tubers can become infected with PMTV. However, if the field also harbors the powdery scab pathogen, the vector can acquire the virus from contaminated seed tubers and hence spread the disease to progeny tubers. Healthy plants can become infected by PMTV if they encounter a viruliferous vector (one that contains and can transmit PMTV). Once a field has both the virus and the powdery scab pathogen, PMTV problems in that field can persist and potentially increase, regardless of the presence or absence of PMTV in seed used in subsequent crops.

Infection. Infection of healthy plants in an infested field typically occurs early in the growing season, during vegetative growth and tuber set. Cool, moist conditions favor powdery scab development and it is under these conditions that PMTV transmits and the symptoms develop and persist.

When the PMTV carrying vector infects root cells, the virus is released into the cells, where it replicates and generates more viral particles. These newly assembled viruses leave the cell and enter others. The individual viruses continue to spread locally via cell-to-cell movement, but they also enter the phloem and travel systemically in the plant.

Dissemination. Mechanical transmission of PMTV from potato to potato is extremely inefficient and rare. In the absence of the powdery scab pathogen, little to no in-season spread of PMTV occurs—PMTV-infected seed tubers give rise to plants that produce only a portion of PMTV-infected progeny tubers. As a result, although PMTV-infected tubers can introduce the virus into a clean field, the powdery scab pathogen is critically important in the wider dissemination of PMTV within a field.

Survival of inoculum. PMTV survives winter in infected stored tubers or in its soilborne vector, the powdery scab pathogen.

Management

Cultural management strategies. Since few options are available to effectively manage PMTV, the best tools available focus on cultural approaches. The most important strategy is to keep PMTV off the farm by planting seed potatoes that are free of PMTV. Currently, no seed potato certification program in the United States requires regulation of PMTV, except as part of a general tolerance for nonspecified internal or external blemishes at shipping-point inspections. Thus, the impetus is on the buyer to have seed or soil tested for PMTV using a laboratory-based test. Both *S. subterranea* and PMTV can be detected in soil using molecular tools such as quantitative polymerase chain reaction (PCR) tests, although at present the threshold for disease development has not been determined. Nevertheless, quantitative PCR tests can be used to monitor the amount of the pathogen potentially present in the seed or soil samples.

Once PMTV is introduced via contaminated tubers into a field that contains the vector (the powdery scab pathogen), it is considered soilborne. Thus, keeping infested soil from moving to clean fields is essential. Before using equipment in clean fields, remove all soil from equipment. Also, avoid discarding tare dirt from infested fields into clean fields.

Increasing the crop rotation interval between potato crops may help slow the spread of PMTV within a field. A rotation of five years or more may help preserve the utility of a field for growing potatoes. Fields severely infested with PMTV may need to be abandoned from potato production entirely, for many years or even decades.

Applying cultural practices that aim to reduce the amount of the powdery scab pathogen in the soil (the vector) may also help reduce the spread of PMTV in an infested field (see Bulletin 1024 on powdery scab for more information).

Resistant varieties. Research conducted in Idaho, Washington, Colorado, and North Dakota demonstrate that variety response to PMTV can vary widely by year and location. Some varieties develop few to no tuber necrosis symptoms and are classified as insensitive to PMTV; however, these "insensitive" varieties may more accurately be "tolerant," in that they may still harbor the virus. Varieties with tuber necrosis symptoms are classified as sensitive, meaning they are both susceptible to the virus and exhibit visual necrotic tuber symptoms. Table 1 shows the reaction of selected potato cultivars that have been visually assessed for PMTV symptom expression in tubers in controlled experiments conducted in naturally infested fields over two or more years (adapted from both published and unpublished data). Although some varieties are listed as "tolerant," it is important to emphasize that "tolerant" does not mean "resistant." That is, a variety may still carry PMTV yet show no symptoms. Such latent infections (where symptoms are not apparent) can result in an inadvertent introduction of the virus into a previously PMTV-free field that may be harboring the powdery scab vector.

Table 1. Selected potato varieties and responses to developing necrotic tuber symptoms due to infection by PMTV. Adapted from Domfeh et. al. 2015 and Yellareddygari et. al. 2018 and unpublished observations from the Pacific Northwest in 2012 and 2014.

Cultivar	Skin color	Relative response category
Alpine Russet	Russet	Sensitive
Alturas	Russet	Moderately Sensitive
Atlantic	White	Moderately Tolerant to Tolerant
Austrian Crescent	Yellow, Specialty	Tolerant
Bannock Russet	Russet	Tolerant
Castle Russet	Russet	Tolerant
Centennial Russet	Russet	Tolerant
Chieftain	Red	Sensitive
Chipeta	White	Tolerant
Ciklamen	Red	Moderately Sensitive
Classic Russet	Russet	Moderately Sensitive
Clearwater Russet	Russet	Sensitive
Dark Red Norland	Red	Sensitive
Lamoka	White	Tolerant
Ranger Russet	Russet	Sensitive to Moderately Tolerant
Russet Burbank	Russet	Sensitive to Moderately Tolerant
Russet Norkotah	Russet	Moderately Tolerant to Tolerant
Russet Norkotah 278	Russet	Moderately Sensitive
Russet Norkotah 296	Russet	Moderately Tolerant
Russet Norkotah CO3	Russet	Moderately Tolerant
Russet Norkotah CO8	Russet	Moderately Tolerant
Shepody	White	Moderately Sensitive
Teton Russet	Russet	Moderately Sensitive
Umatilla Russet	Russet	Tolerant
Yukon Gold	Yellow	Moderately Tolerant to Tolerant

Biological control options. No biological control products are currently available that effectively manage PMTV in potato.

Chemical options. There are no chemical control options that directly target the virus. Options for chemical management of the vector (the powdery scab pathogen) are limited and inconsistent (see Bulletin 1024 for more information).

Diagnosing PMTV

Managing PMTV depends on an accurate diagnosis. Since symptoms that look like PMTV or powdery scab (caused by the vector of PMTV) can appear to be absent, difficult to see, or caused by other organisms, a correct diagnosis is best achieved by using sensitive laboratory tests designed to detect the pathogens.

Conclusion

Currently, there are no control measures for PMTV. The best strategies include being aware of the disease and how it is spread; using quality certified seed; and obtaining accurate diagnoses based on laboratory tests. If PMTV and its vector are found in a field, it may be necessary to implement strategies to minimize the spread within and among fields to prolong the utility of fields for potato production for years to come. Samples of tubers and soil can be submitted to the UI's Plant Diagnostic Services for analysis.

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