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Necrotic Potato Tuber Symptoms Caused by Strains of *Potato virus Y*

Jonathan Whitworth
Plant Pathologist, United States Department of Agriculture-Agricultural Research Service

Melinda Lent
Research Associate, University of Idaho, Idaho Falls Research and Extension Center

Nora Olsen
Extension Potato Specialist, University of Idaho, Kimberly Research and Extension Center

Alexander Karasev
Distinguished Professor, University of Idaho

Kasia Duellman
Extension Seed Potato Specialist, University of Idaho, Idaho Falls Research and Extension Center

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Introduction

A PATHOGEN OF POTATO, *Potato virus Y* (PVY), causes a disease known as common mosaic on potato. It can be a serious challenge for early generation seed potato growers whose seed crop must have less than 1% incidence to be eligible for recertification (to be increased again for seed). Not only can tuber-borne PVY limit yield, strains of the pathogen also affect quality for the commercial grower by causing necrotic lesions on or within potato tubers. In the syndrome known as potato tuber necrotic ringspot disease (PTNRD), ring-shaped lesions occur externally on the tuber. However, necrotic lesions associated with PVY can also occur deep within tubers. The occurrence of these symptoms depends on interactions among the strain of virus, the potato variety, and the environment. Such symptoms may lead to rejection by processors or during shipping-point inspections if incidence exceeds accepted thresholds.

Strains of *Potato virus Y*

Many different strains of PVY compose populations of the virus. The PVY strain composition in seed potatoes planted in the Pacific Northwest (PNW) has shifted from being comprised mainly of the ordinary strain (PVY^{O}) to predominantly including newer, recombinant ones. The most commonly occurring strains in the region are now the recombinant strains known as N-Wilga ($PVY^{N\text{-}Wi}$) and NTN (PVY^{NTN}). Both of these strains have recombinant genomes built of genome segments from two parental strains, PVY^{O} and PVY^{N}. The ordinary strain, PVY^{O}, is nearly extinct in seed potatoes grown in the region as of 2022 and PVY^{N} has not been found in the PNW since 2011. In the United States, the PVY^{NTN} strain is most often associated with PTNRD, since other PVY strains linked with this syndrome are either absent or very rare in the United States. Isolates of $PVY^{N\text{-}Wi}$, $PVY^{N:O}$, PVY^{NTN}, and PVY^{O} may also cause necrotic lesions deeper within tuber tissue.

Though PVY may cause foliar symptoms (such as mosaic, stunting, defoliation, necrotic lesions, complete plant death, and others), the presence or absence of foliar symptoms do not predict whether

tubers will develop symptoms. Foliar symptoms depend on the virus strain, potato variety, and environment and they may be difficult to see or absent.

The nomenclature for the various PVY strains is straightforward: NTN stands for "Necrotic-Tuber necrosis", N:O stands for a combination between strains N and O, and N-Wi was named for the necrotic-Wilga strain first found in Poland. Incidentally, early surveys made no distinctions between N:O and N-Wi due to genetic similarities.

Necrotic Tuber Symptoms Associated with PVY

The disease PTNRD is a distinct syndrome that causes necrotic rings on the tuber surface (Figure 1). Symptoms may start as small water-soaked lesions that expand over time into raised, swollen rings. Early symptoms on the tuber may initially be accompanied by a pinkish discoloration. The rings later become sunken and necrotic, protruding into the tuber flesh directly under the skin. The disease affects certain potato cultivars that are susceptible to PTNRD, such as Yukon Gold. Lesions may lead to ruptures in the tuber skin, allowing entry of secondary pathogens such as those that cause Fusarium dry rot or bacterial soft rot. Internal symptoms may be associated with the external symptoms, occurring directly beneath the external symptoms and extending partially into the tuber tissue.

Strains of PVY may also cause internal symptoms deeper within tuber tissue, appearing as brown (necrotic) spots, arcs, lines, or ring-shaped lesions (Figure 2). These deeper necrotic lesions inside tubers are not always associated with PTNRD, but they can still negatively affect quality.

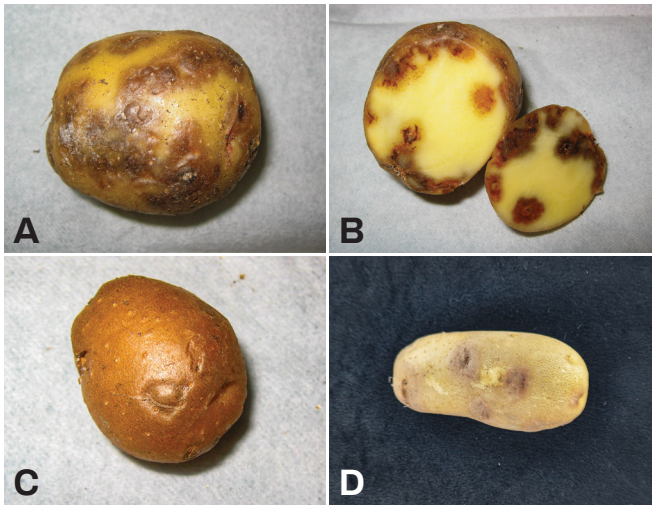

Figure 1. External (**A**, **C**, **D**) and internal symptoms (**B**) associated with potato tuber necrotic ringspot disease.

Conditions That Favor Development of Necrotic Symptoms on or within Tubers

The development of necrotic lesions due to PVY on or within potato tubers is dependent on the interactions among virus strain, potato variety, and the environment. Some potato variety and strain combinations may be more prone to developing the internal lesions. Research shows that at least four strains (PVY^{O}, $PVY^{N\text{-}Wi}$, $PVY^{N:O}$, and PVY^{NTN}) can cause PTNRD (Table 1). Both internal and external symptoms can continue to develop over time in storage, although the virus does not move from infected to healthy tubers in storage. The type of environment that promotes symptom expression is not fully understood, but anecdotal observations suggest that incidence may be higher during hot and/or stressful years.

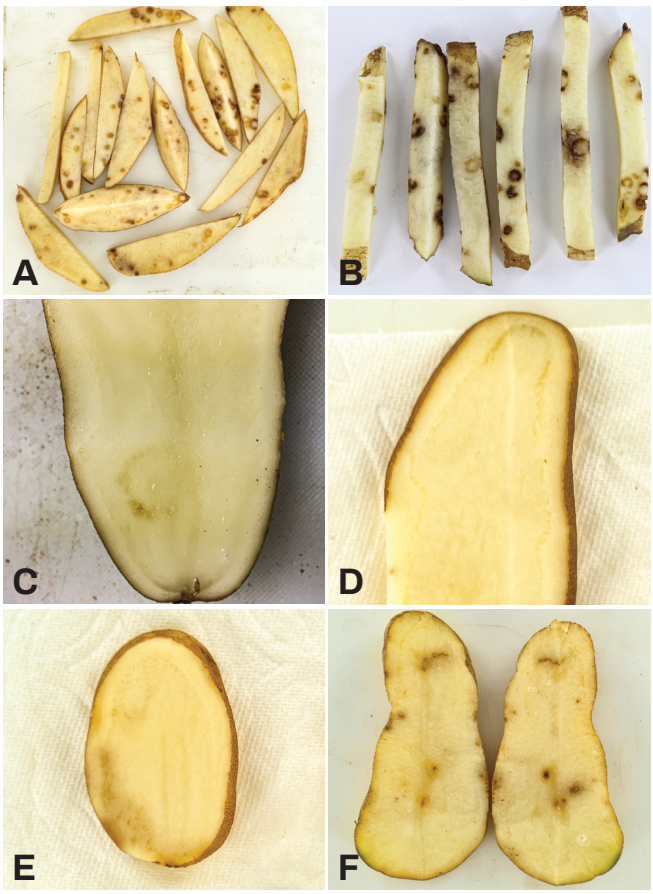

Figure 2. **A–F**, Various internal tuber symptoms associated with infection by strains of PVY.

Table 1. Potato tuber necrotic ringspot disease (PTNRD) symptoms in potato varieties by strain of *Potato virus Y* (PVY) and variety market class. Multiple isolates of the virus for each strain of PVY were evaluated and assays were conducted under greenhouse conditions in Idaho and New York. A plus sign (+) means PTNRD developed in that variety when inoculated with at least one PVY isolate. If a variety has no plus sign (+) for a particular virus strain, then PTNRD was not observed for that combination of PVY strain and potato variety. Variety and PVY strain combinations with an asterisk (*) indicate a potentially higher risk for development of PTNRD. Varieties were not evaluated for internal symptoms (modified from Whitworth et al. 2021).

	Strain of *Potato virus Y*			
Variety	**PVY^{O}**	**PVY^{NTN}**	**PVY$^{N:O}$**	**PVY^{N-Wi}**
Russet Varieties				
Alpine Russet				
Alturas			+	+
Bannock Russet		+		
Blazer Russet				
Centennial Russet				+
Classic Russet	+			
Clearwater Russet				
Dakota Russet				
Dakota Trailblazer				
Freedom Russet				
GemStar Russet				+
Goldrush				
Highland Russet	+	+*	+	+
Mountain Gem Russet				
Payette Russet				
Pomerelle Russet				
Premier Russet				
Russet Norkotah				
Russet Norkotah 278				
Russet Norkotah CO8				
Ranger Russet	+	+*	+	+
Russet Burbank		+	+	
Silverton Russet				
Targhee Russet				
Tebina Russet				
Teton Russet				
Umatilla Russet				
Chipping Varieties				
Andover				
Atlantic				
Chipeta				
Chippewa	+	+*	+*	
Dakota Crisp				+
Eva				
Kennebec				
Lamoka				
Marcy	+*			
Megachip				
Nicolet				+
Pike	+*	+	+	+
Pinnacle				
Snowbird				
Snowden				
Superior				
Waneta	+*	+*		
Red-Skinned Varieties				
Chieftain				
Ciklamen				
Colorado Rose				
Dakota Jewell				
Dakota Ruby				
Desiree				
Modoc				
Red Endeavor				
Red Gold				
Red LaSoda				
Red Norland				
Red Thumb				+
Rio Colorado				
Specialty and White Varieties				
Bintje				
Calwhite				
French Fingerling				
Gala				
Katahdin	+			
Oneida Gold				
Russian Banana				+
Shepody				
Yukon Gem	+*	+*	+*	+*
Yukon Gold	+*	+*	+*	+*

Diagnosis and Look-Alikes

Symptoms are not always classic in appearance. Necrotic lesions within tubers caused by PVY can resemble those caused by Tobacco rattle virus (*Tobravirus tabaci*; vectored by stubby root nematodes) and Potato mop-top virus (*Pomovirus solani*; vectored by the soilborne protozoan *Spongospora subterranea*). Physiological factors can also cause similar defects. Laboratory tests confidently distinguish among the causes of necrotic lesions due to viruses. Molecular and serological laboratory tests are available from testing labs such as the University of Idaho Plant Diagnostic Services (https://www.uidaho.edu/cals/plant-diagnostics).

Management

Management strategies are usually aimed at the seed potato grower. For more information, see University of Idaho Extension Bulletin CIS 1165, *Potato Virus Y Management for the Seed Potato Producer* (https://www.uidaho.edu/extension/publications/publication-detail?id=cis1165).

For the commercial grower:

- Select high-quality, certified seed with low incidence of PVY based on postharvest laboratory testing.
- Use seed that is free from external or internal blemishes that are confirmed to be caused by virus.
- Insecticides alone are ineffective for PVY management and can make the problem worse. Due to aphid vectors rapidly taking up and disseminating PVY before an insecticide can kill them, targeting aphids for PVY management is not recommended for the commercial grower. Note: Aphid management by the commercial grower is an effective strategy for other aphid-vectored viruses such as Potato leafroll virus, where the aphids acquire and transmit the virus much more slowly.
- Some potato varieties appear to be highly susceptible to necrotic symptoms on tubers (such as Ranger Russet, Yukon Gold, Yukon Gem, and Highland Russet) and at higher risk of developing PTNRD.
- When possible, choose potato varieties that do not appear to be susceptible to necrotic tuber symptoms, such as Russet Burbank, Russet Norkotah, Clearwater Russet, Castle Russet, Payette Russet, and Teton Russet; red varieties such as Ciklamen; chipping varieties such as Eva, Saginaw Chipper, AAC Alta Crisp, Lady Liberty, and Mackinaw; and specialty varieties such as Bintje AAC Confederation (yellow skin, yellow flesh) and Upstate Abundance (high set, baby potatoes).
- Extreme resistance to PVY comes from a dominant resistance gene known as Ry that confers resistance to multiple strains of PVY. Breeding programs are using potato lines and varieties with this extreme PVY resistance trait to incorporate PVY resistance into new varieties. Varieties that currently have extreme resistance conferred by Ry genes include Payette Russet, Castle Russet, Eva, Mackinaw, Saginaw Chipper, Lady Liberty, AAC Alta Crisp, AAC Confederation, Upstate Abundance, and Ciklamen. In the future, more PVY-resistant potato varieties with Ry genes will become available.

Summary

The potato pathogen known as *Potato virus Y* can cause necrotic lesions within tuber tissues as well as the syndrome known as potato tuber necrotic ringspot disease (PTNRD) that affects tubers externally. Tubers may be rejected at shipping-point inspections or by processors if defects are above the tolerance level. Though all PVY strains can cause tuber symptoms, PVY^{NTN} is the most notable strain and the incidence of this strain in the Pacific Northwest appears to be on the rise. Extreme resistance to all known strains of PVY is available and breeders are working to incorporate this trait into desirable potato varieties. Such host resistance is the best option for managing PTNRD.

Further Reading

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