

Potato Virus Y Management for the Seed Potato Producer

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About PVY strains

Current discussions about PVY are filled with confusing references to new and different virus strains. Hopefully this information will help to clear up some of the confusion.

PVY^O is the original wild strain of PVY. The ^O stands for “ordinary.”

PVY^N is one of the strains new to the United States. The ^N stands for “necrotic,” which means “dead.” These strains cause a necrotic reaction on tobacco leaves but not on potato foliage. In fact, these strains of PVY usually cause milder symptoms in potato than those caused by PVY^O.

PVY^{NTN} is a PVY^N type that causes necrosis on tobacco but can also cause necrotic flecking and ringspot symptoms in the tubers of some potato varieties. The ^{NTN} stands for “n - tuber necrotic.”

PVY^{N:O} These strains are thought to be “recombinants,” which means that they have some characteristics of both PVY^O and PVY^N.

“The maturity and harvest of cereal crops in late June or early July are probably the main causes for this sudden spike in aphid incidence. As aphids move out of the ripening grain, they are attracted to remaining green vegetation in the vicinity—the potato crop. Large numbers of migrating aphids can greatly increase the spread of PVY within potato seed fields that are close to maturing cereal fields.”

One of the most serious challenges facing seed potato producers is managing *Potato virus Y* (PVY), also known as “common mosaic” or “potato severe mosaic.” This virus causes a range of symptoms in infected potato plants, varying with potato varieties (Figures 1 and 2).

Stunting and foliar mosaic symptoms typical of PVY infection can be seen in Russet Burbank or Red Norland varieties. However, a number of potato varieties display mild symptoms or no symptoms at all (latent infection) when contaminated with the virus. These varieties, often referred to as “PVY carriers,” include: CalWhite, Gem Russet, GemStar Russet, Russet Norkotah (all strains), Shepody, and Silverton Russet (Rykbost et al., 1999; Nolte et al., 2002). PVY infection in varieties such as Ranger Russet may cause severe foliar damage, wilting, and even death of the entire plant. This range of symptom expression is characteristic of the “ordinary” strain of the virus—designated as “PVY^O.”

Unfortunately, new strains of PVY making their way into the North American seed potato system cause milder foliar symptoms or are latent in many varieties. Although they cause less severe foliar symptoms, some of these new strains can induce necrotic symptoms in tubers (Figure 3).



Figures 1 a,b,c. PVY symptoms range from severe to mild. This is illustrated by the severe stem browning and brown curled leaf in Highland Russet with PVY^{NTN} (1a). Compare that with healthy Highland Russet (1b) and with the mild white splotchy symptom in Alturus infected with PVY^{NTN} (1c).

Virus transmission by aphid or mechanical contact

Plant viruses such as PVY are incapable of movement on their own. The two most common methods of PVY movement are by aphid vectors and mechanical transmission.

During mechanical transmission (also called sap transmission), PVY is spread by contact between infected and healthy plants resulting in short-distance spread of the virus. This transmission requires a wound, which can be caused by plant-to-plant contact from wind or human activity.

Oregon research found that healthy potato plants adjacent to seed-borne infected plants had become infected by the season's end.

In very susceptible varieties, plants further away in the row and even across the row from the seed-borne infected plants were also likely to become infected (Hane and Hamm, 1999). In spite of these findings, mechanical transmission of PVY is considered to be a slow and inefficient means of spread, resulting in less movement when compared to transmission by aphids.

Aphids: most efficient at transmitting PVY

Far more important for transmission of PVY is the spread that occurs by action of a mobile agent called a "vector." In this case, the vector is an aphid. For PVY, the aphid vector could be any of more than 50 aphid species from an ever-growing list.

Also important, the spread occurs in what is termed "stylet borne" or "nonpersistent" transmission. Viruses transmitted in this manner are present in high concentrations in the outer cell layers within the leaves. Aphids acquire the virus during the brief process of aphid probing or feeding on an infected plant when virus particles attach to their mouth parts called stylets. The contaminated aphid then transmits the virus within a few seconds while performing the same probing or feeding activities on other plants.

The virus remains viable on the aphid's mouthparts for a relatively short time, usually less than 2 hours, hence the "nonpersistent" designation. The aphid must repeat this feeding activity on another infected plant to reacquire the virus.



Figures 2 a, b, c. Compare symptoms of PVY damage in foliage of Ranger Russet plants: 2a shows infection with PVY^{NTN} while 2b is infected with PVY^O. The plant in 2c is healthy.

Viruses that are nonpersistently transmitted can spread very rapidly, and, if aphid populations are large, spread can be very extensive. Younger plants are more easily infected than older ones, and the time required for virus translocation to the tuber is shorter in young plants than it is for more mature ones (Sigvald 1998).

Why insecticide applications seem ineffective

Unfortunately, insecticide applications, even in-furrow at planting or seed treatments with systemic materials, have proven to be ineffective for control of PVY in potatoes. This lack of control is due to two factors:

First, the time required for the aphid to acquire and transmit the virus is very short, measured in minutes or even seconds. Under these conditions, the insecticide cannot act rapidly enough to kill the aphid before the virus is transmitted.

Second, since acquisition and inoculation occur so quickly, vectors do not need to colonize potatoes to transmit PVY. Therefore, aphids responsible for the spread of potato mosaic viruses can come from other crops, shrubs, weeds, etc.

Beware the bird cherry-oat aphid

At this time, it appears that the bird cherry-oat aphid (Figure 4) is probably the most important vector. Even though transmission efficiencies for PVY by this aphid are relatively low (below 11%), any lack of efficiency is overcome by sheer numbers.

This aphid is by far the most abundant cereal aphid in the Pacific Northwest and frequently occurs in seed potato production areas. It is present on grain crops from April to July and in the fall. Colonies are often found on the underside of leaves or on leaf sheaths and heads of cereals.

Watch for early July aphid colonies

Colonization can be particularly abundant on maturing corn, with dense colonies often covering ear sheaths and leaves. Bird cherry-oat aphid population peaks in eastern Idaho between the first and second weeks of July.



Figure 3. The new PVY strains cause less severe foliar symptoms. However, some of them can induce necrotic symptoms in tubers. Tubers from plants infected with different PVY strains displaying necrotic symptoms are pictured here: (3a) Highland Russet with PVY^{NTN}; (3b) Alturas with PVY^{NTN}; (3c) Yukon Gem with PVY^{NTN}; Yukon Gem external (3d) and internal (3e) symptoms of PVY^{N:O}; (3f) Ranger Russet with PVY^{N:O}.

Insecticide applications reduce potato leafroll virus

Management of another important potato virus—the Potato leafroll virus (PLRV)—can be achieved with insecticide applications because this virus transmission process is much more complex and requires a great deal more time than PVY transmission.

PLRV is restricted to the vascular tissues of the plant, and only aphids that colonize potatoes—such as green peach aphid, potato aphid, and a few other species—are capable of transmitting this virus.

To acquire the virus, aphids must probe deeply enough to feed on the plant's vascular tissues. Once the virus has been acquired, another 24 to 48 hours are needed for the virus to circulate through the aphid's body before it can transmit the virus. Because of this time lag, insecticides that prevent infestation of the potato crop by colonizing aphids can be effective in preventing the spread of PLRV.

The maturity and harvest of cereal crops in late June or early July are probably the main causes for this sudden spike in aphid incidence. As the aphids move out of the ripening grain, they are attracted to the remaining green vegetation in the vicinity—the potato crop. Large numbers of migrating aphids can greatly increase the spread of PVY within potato seed fields near maturing cereal fields. The aphids migrating out of the grain crop may land on and probe virus-infected potato plants or infected alternate weed hosts. Then they probe healthy plants, resulting in the virus spreading.

Bird cherry-oat aphids (Figure 4) are small ($\frac{1}{8}$ inch), yellowish-green to dark green to dull black aphids, characterized by a reddish-orange spot on the backend at the base of the cornicles (tube-like structures located at the dorsal end of their bodies). The leg tips, cornicles, and antennae of this species are black.



Figure 4. Bird cherry-oat aphid adult and nymphs are pictured. This aphid—by far the most abundant cereal aphid in the Pacific Northwest—appears to be the most important PVY vector. Photo by Juan M. Alvarez, University of Idaho

Mature aphids found in winter and early spring may display the color of a blueberry, but they will give birth to more typical (green) aphids in the spring. The winged form of this aphid tends to be darker than the wingless form.

Infected seed potatoes are major sources of PVY virus

Infected seed potato tubers are by far the most important source of virus for each new season, but other host species can also play a role. PVY has a wide host range. Approximately 120 plant species, including a number of weed species, have become infected by mechanical transmission under laboratory conditions.

Hairy nightshade. While infected seed potatoes are thought to be the most important source of PVY, weed hosts such as hairy nightshade may also play a role in virus spread. Fortunately, PVY does not transmit through true seed so nightshade, which establishes from season to season from true seed, does not emerge with PVY infection. However, nightshade, a commonly occurring weed in the Pacific Northwest, is not only susceptible to PVY, it is also very attractive to potato-colonizing aphids (green peach and potato aphids) and could well be a source of infection for seed producers, especially late in the season.

Research in Idaho reveals that hairy nightshade can easily become infected with potato leafroll virus (PLRV). Research also showed that transmission of PVY by the three aphid vectors was higher in field plots with a PVY-infected hairy nightshade plant as source of virus inoculum than in plots with only a PVY-infected potato plant.

Mosaic virus management for the seed producer

Don't plant a problem

The most important management tool available to the seed producer is to acquire and plant seed potatoes with extremely low or zero levels of PVY. Aphids do not usually carry the virus into seed fields (although this can happen); it is far more likely that they spread virus that already exists in the field. Under these circumstances, it is easy to see why planting seed lots with zero or extremely low levels of mosaic virus is the recommended practice.

Ask for results of the winter test for the seed you plan to purchase, and make sure that the level of PVY was determined by a laboratory test such as ELISA (enzyme-linked assay). Additionally, since hairy nightshade is both a reservoir of green peach aphids and also a more efficient inoculum source of PLRV and PVY than potato, we strongly recommend the control of this weed in seed-growing fields.

Roguing—remove mosaic-infected plants

Walk your fields and remove any infected plants that you find. This process, called “roguing,” is still a highly effective method of reducing the level of inoculum. The earlier in the season that infected plants are rogued out, the lower the amount of spread. Remember that an infected plant not removed from the field is very likely to infect its two neighboring plants at the very least. It is important to note (as previously mentioned), that some of the new PVY necrotic strains that induce necrosis in tubers may not cause visual symptoms on potato plants.

Promising: Apply insect repellent or behavior-altering pesticide

As explained before, insecticide applications for aphid control do not effectively decrease PVY transmission due to the nonpersistent virus-transmission mode. However, several new

insecticide products, especially those that alter aphid-feeding behavior, appear to be at least somewhat effective in reducing aphids and PVY spread.

Preliminary research in Idaho measured the abilities of several of these newer and softer insecticides to reduce aphids and PVY spread.

The following insecticides (in alphabetical order) were found to provide good to excellent aphid control:

- acetamiprid (Assail®) Group 4A
- clothianidin (Belay®) Group 4A
- imidacloprid (Admire Pro®) Group 4A
- pymetrozine (Fulfill®) Group 9B
- spirotetramat (Movento®) Group 23
- thiamethoxam (Platinum®) Group 4A

These were found to reduce PVY transmission:

- clothianidin (Belay®) Group 4A
- imidacloprid (Admire Pro®) Group 4A
- imidacloprid (Provado®) Group 4A
- pymetrozine (Fulfill®) Group 9B
- spirotetramat (Movento®) Group 23

To prevent or delay resistance to insecticides, potato growers must rotate the mode of action of insecticides. To help growers figure out what product belongs to what mode of action, insecticides are classified by their mode of action. In the list above, the group number follows each insecticide. Growers should avoid following the application of an insecticide with another insecticide from the same group.

Additional research is currently underway in Idaho to determine which insecticide will best exploit the combination of aphid mortality and PVY transmission reduction to produce the lowest final percentage of virus infection in the field.

Management practices that help

Management practices that can help reduce the spread of PVY to some degree include the application of crop oil to foliage on a regular basis, especially just before and during periods of peak aphid activity.

Apply crop oils from July to vine kill

Crop oils appear to interfere with virus transmission, although the exact means by which this interference is accomplished remains unknown.

Aphid trapping and monitoring systems operated during the last 6 years in Idaho indicate that application of crop oil or other repellent or behavior modifying insecticides should begin in the last two weeks of July and should continue until vine kill. The highest levels of aphid activity have occurred during the first two weeks of July and the first two weeks of August. In order to be effective, a repellent spray program would have to be in effect for this period of maximum aphid activity at the very least.

Crop borders—aphid-cleaning stations

Crop borders, which consist of a non-PVY host crop, can be planted around small early-generation seed lots to provide a buffer between the seed lot and the in-flight of aphids. Aphids usually land at the interface between fallow ground and green crop. Therefore, border crops should be adjacent to potatoes and surrounded by fallow. Aphids landing on the border crop should “clean up” their stylets and lose their vectorial capacity.

Research in the Midwest by Difonzo et al., (1996) showed that crop borders around small plots resulted in lower PVY in the resulting winter grow-out than did fallow-bordered crops. Recent results have indicated that when virus is within the lot, the effect of a crop border is lost (Davis, J.A., pers. communication).

This crop border effectively serves as a cleaning station for aphids that come into the crop with PVY. Since PVY is a stylet-born virus, virus particles attached to the stylet get left in the tissue when an aphid probes a plant. If this plant is part of the crop border, then when the aphid enters the small seed lot, its stylet is clean. Growers in Idaho have effectively used wheat borders planted in the spring so that the border stays green all summer.

Kill vines as early as possible

Finally, early vine kill can reduce virus spread to tubers. Killing the vines as early as possible can interrupt the translocation of virus from the foliage to the tubers but only if the foliar infection has occurred fairly recently. Translocation of

the virus to the tuber requires anywhere from 14 days in very young potato plants to 26 days in mature plants (Sigvald, 1998).

Note that early vine kill may result in some yield loss if the crop is still actively growing, but the trade off in lower levels of virus infection may be worth some yield loss.

Role of volunteer potatoes

Volunteer potatoes can be a virus inoculum source. Surveys for mosaic virus performed by the University of Idaho indicate PVY levels of up to 2 percent in some volunteer samples. Volunteers should be controlled by application of an approved herbicide.

Summary

The single most important management practice is using seed lots with zero or very low levels of virus to plant your seed crop. Application of insecticides, crop oil, and use of crop borders, along with early vine kill can reduce, but probably will not eliminate, virus spread. Using all three of these practices in combination provides the best possible control.

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