2018 Montana Seed Potato Virus and Aphid Management Guide

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Key points for successful management

- **Isolate seed plots, and nuclear production from G1 as much as possible.**
  - **Plant border crops.**
  - **Apply mineral oils early. Begin no later than 25-30% emergence. Timing is especially critical for nuclear and G1.**
- **Foliar applied insecticide-only programs do not control vector transmission.**
- **Programs including timed mineral oil applications and insecticides are the most effective management strategies.**

Potato viruses are one of the most serious and limiting disease factors affecting potato production throughout the world. Management of potato viruses in seed potato production is critical. Integrated pest management (IPM) approaches have proven to be the most successful for controlling the diseases.

Viruses in Potato

Viruses can be transmitted either by a vector, such as aphids, nematodes or fungi, or mechanical transmission. In Montana, the most important virus diseases are spread by aphids. There are two main classes based on the mode of aphid transmission of the virus affecting potato. Aphids transmit them in two basic ways. The virus is either non-persistent (stylet- borne) or persistent circulative (they are ingested and persist in the aphid throughout its life). The mode of transmission of viruses has a critical effect on the selection of management programs. Common non-persistent or stylet-borne viruses are *Potato virus Y* (PVY), *Potato virus A* (PVA), *Potato virus S* (PVS), and *Potato virus M* (PVM). For most stylet-borne viruses, the virus is acquired immediately and can stay viable on the stylet for up to 2 hours. In non-persistent transmission the virus is transmitted as soon as the aphid stylet penetrates the epidermal cells of the leaf- **too soon for any insecticide to kill the aphid and prevent virus transmission**. *Potato virus X* (PVX) is a mechanically transmitted potato virus. Cutting, cultivating, human and animal movement, and wind-driven hail can spread PVX. Sanitation at all stages of crop management is essential.

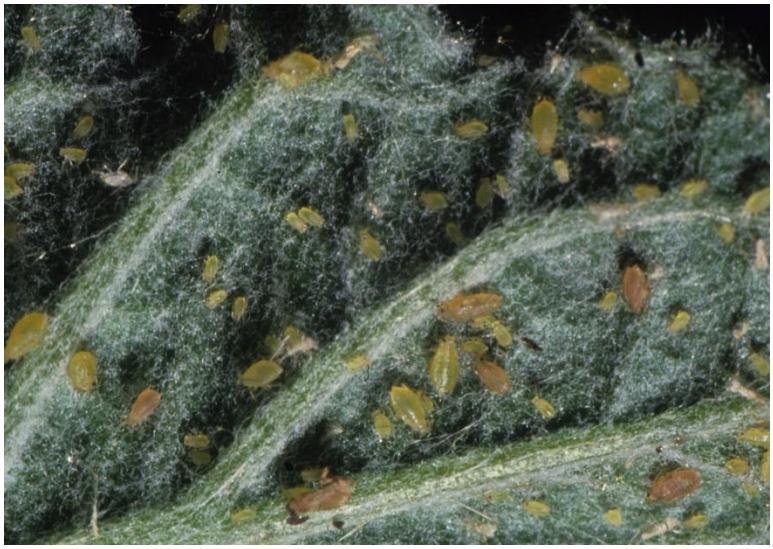
The most common persistent circulative virus affecting potatoes in Montana is *Potato leaf roll virus* (PLRV). The aphid must feed for more than several minutes to transmit persistent-circulative viruses, making control by insecticides highly effective. The near absence of PLRV in recent years is primarily due to the effectiveness of seed treatment or in-furrow insecticides neonicotinoids such imidacloprid-based products (Admire Pro, Gaucho, Nuprid, Mana Alias, etc.) or thiamethoxam based-products (Platinum or Cruiser) and season-long insecticide programs. These materials will provide 60+ days of **colonizing** aphid control from time of application.

Remember that aphid/PLRV control is needed until vines are dead. While use of oils alone will help in control of PVY, oils will not help control PLRV.

Aphid Vectors and Host Plant for Potato Viruses

More than 50 aphid species can transmit PVY. Aphids can be either colonizing or migratory. Colonizing aphids such as the green peach aphid overwinter in Montana on *Prunus* species as eggs or colonize weeds such as hairy nightshade, mustards, ground cherry, tumble mustard, flixweed, shepherds purse, chickweed, mallow, horseweed, pennycress, redstem filaree, and bedding plants. Control of aphids on bedding plants or over wintering host plants is an important component of any IPM aphid/virus control program since these plants can also be sources of both aphid vectors and viruses. Some aphids such as the green peach or potato aphid can colonize potato, others including the common, bird cherry-oat aphid, will not colonize potato but are common in grain crops. Winged migrants originate from 10s to 100s of miles away.

Non- potato colonizing aphids that transmit non-persistent viruses can migrate as winged adults to potato fields from alfalfa or small grains as these crops are cut or mature. They generally alight on field edges and move through the potato planting, attempting to feed and moving on. This can be a major factor in spreading non-persistent viruses such as PVY. **Removing in-field sources of virus by rogueing is critical. Our research has shown this accounts for 40-50% of the reduction in PVY.** Migrating aphids typically will land on edges of vegetation. Therefore, border crops with no breaks between the border crop and potatoes, will serve as "aphid cleaning stations", since once the aphid probes the non-host border crop the virus is removed from the stylet.



Green peach aphid on potato.
Photo: Jim Baker, North Carolina State University, Bugwood.org

Types of virus transmission

Non-persistent—Viruses attach to the vectors mouthparts, also referred to as stylet-borne. Vectors can transmit and pick up the virus from an infected plant in seconds during probing and feeding. When the vector moves to a new plant to feed the virus is inoculated, often within minutes.

Virus-vector example: *Potato virus Y* and aphids

Semi-persistent—Virus enters the foregut of the insect. The vector can acquire the virus in minutes and can transmit for a greater period of time up to several hours. The virus is lost during vector molting.

Virus-vector example: *Cauliflower mosaic virus* and aphids.

Persistent

Persistent circulative—Virus that can circulate through the entire vector. Vectors acquire the virus in hours to days and can transmit up to a few weeks. The virus is retained through molting, but is not passed to subsequent generations.

Virus-vector example: *Potato leaf roll virus* and aphids

Persistent propagative—Propagative viruses are able to replicate in both the plant and the vector. The vector acquires the virus during extended feeding from the phloem. The vector is capable of virus transmission fro its entire life cycle and can pass the virus to offspring.

Virus-vector example: *Tomato spotted wilt virus* and thrips.

MANAGING VIRUS DISEASES IN SEED POTATOES

Planting Disease-free Seed

The first tenant in plant protection is to not plant a problem. Data from multiple years of summer and postharvest testing by the MSU Potato Lab have demonstrated that seed lots with detectable PVY up to 0.1% PVY at summer testing have a significantly reduced chance of remaining below 0.5% PVY at the postharvest test. The majority of seed lots testing over 0.1% PVY during the summer have greater than 0.5% PVY at the postharvest test. It is highly unrealistic that planting anything that tested at greater than 0.5% PVY in the postharvest test will make the recertification target of 0.5%, even after intensive roguing.

Isolation of Nuclear and Generation 1 plots

Isolation and protection of seed plots, especially nuclear, is the most important long-term strategy for PVY management. Research from the MSU Potato Lab has demonstrated that nuclear plants are more susceptible than plants grown from field grown tubers. The historic practice of planting seed plots with nuclear and G1 together can result in catastrophic failure when the G1 families have higher than expected virus. In many cases nuclear seed lots are not tested postharvest so the disease status is unknown and planting the nuclear and G1 together the following season poses a significant risk of infecting nuclear plants. Another historic practice, surrounding seed plots with other potatoes, can be very dangerous unless the surrounding potatoes are 100% clean. Summer test results of as low as 0.05% PVY (~100 plants/acre) in surrounding potatoes can result in significant inoculum to infect nuclear plots. If there are no seed lots available with a high level of confidence in the PVY-free status, it is recommended to plant nuclear plots upwind of any other potatoes with as much isolation as possible. Border plantings of legumes such as peas or soybeans, spring planted winter wheat, corn, or late seeded spring grain will provide a green border around the planting and serve as an inoculum-free zone where aphids will clean their stylets before entering the potatoes. Weed management can be a challenge with the incorporation of crop borders if the border crop is sensitive to the herbicides used on potatoes so herbicide selection is important. An emerging alternative for border plantings are potato cultivars with extreme resistance to PVY including Payette Russet which is resistant to all strains of PVY. It was released in 2014 and to date, no infections of PVY have been detected. Castle Russet was released by PVMI in 2016 and has a similar form of resistance.

Alturas infected with PVY strain NO. Depending on cultivar and strain, PVY can be very difficult to detect.
Photo: Nina Zidack

Ranger Russet infected with PVY strain NO. Subtle mosaic pattern is apparent in leaf tissue.
Photo: Nina Zidack

Roguing

Roguing for mosaic in G2-G4 should be initiated when the potatoes are 8-10 inches tall and should be repeated at least another 1-2 times up until row closure. Roguing in seed plots should be initiated at the same time and should occur on a weekly basis throughout the growing season. In seed plots, every plant in the family (even if only one plant is symptomatic) should be removed. If a family unit tested positive for PVY, all plants should be rogued, even if symptoms are not seen. In all cases, all of the plant material (leaves and stems, seed piece, roots and tubers) should be removed from the field in black plastic bags. Plants that are dug and left on the top of the hill often re-root and provide a guaranteed inoculum source for a week or more. In main fields, if the plants are touching in the row, it is recommended to rogue one plant on either side of the infected plant. Roguing crews should sanitize footwear and shovels before they enter any seed field and when moving between fields. If you are hiring a commercial roguing crew, evaluate their sanitation regimes before they are allowed in the field.

Roguing crews play an integral role in potato virus management, but sanitation must be followed carefully. Removal of dirt and organic matter from of all surfaces including boots and equipment followed by disinfection is critical for sanitation.
Photos: Nina Zidack

Mineral Oils

Mineral oil sprays do not kill aphids, but function to reduce the acquisition and transmission of stylet-borne viruses. They also reduce the time virus particles can be retained on the stylet. There is evidence that mineral oils influence aphid behaviors such as extending the time on foliage without probing, reduced restlessness and flight. They work at the site where aphids probe with their mouthparts; therefore it is critical that coverage be uniform on the leaf and stem. This requires small droplets and high volumes for uniform coverage and frequent application (4-7 days) to protect new growth. Mineral oils should not be applied when plants are wet since this will cause the oil droplets to bead up and will reduced coverage. Mineral oils can be applied to field borders to create "aphid cleaning stations" just like a non-virus host crop border. Successful applications begin at 25-30% emergence and continue until vines are completely dead. Application of crop oils will be most important in late June to mid July when alfalfa is cut or grain ripens and non-colonizing aphids migrate as winged adults from these fields where they can no longer feed. Application should occur at shorter intervals when the crop canopy is growing rapidly and can go to weekly intervals as canopy growth slows. There is limited evidence of phytotoxicity of co-application of oils with Chlorothalonil (Bravo, etc.) and TPTH (SuperTin, AgriTin). Mancozeb-based fungicides appear to be safe. Common mineral oils are referenced in Table 1.

Insecticides

Chemical control of aphid virus vectors should begin just prior to the expected time of decline of soil or seed treatment insecticides till vines are completely dead. Effective residues of soil and seed treatment insecticides last 60+ days from planting depending on soil and environmental variables. **Any gap in insecticide protection until total vine kill occurs can result in significant virus transmission**. Insecticide resistance in green peach aphid is common (some researchers consider that many populations are resistant to the synthetic pyrethroid insecticides such as Asana, Pounce, Ambush, Baythroid XL, Warrior, Mustang Max, etc.- the status of resistance in Montana is unknown) and resistance management precautions should be observed. In addition, the use of synthetic pyrethroid class 3 or organophosphate insecticides class 1 will kill rapidly, but may result in increased aphid infestations due to mortality of aphid predators and parasites.

In addition, there is some evidence that use of these insecticides will cause increased aphid movement amongst survivors, thus increasing spread of stylet-borne viruses. It is important to understand which chemical class of each insecticide used so that the aphid population is not sequentially exposed to the same class (mode of action). This is particularly important for neonicotinoid insecticides –class 4A (Admire, Gaucho, Provado, Platinum, Actara, Cruiser, Assail, Belay, Nuprid, Venom) where foliar neonicotinoids sprays should not follow neonicotinoid planting time or seed treatments. Table 2 provides information on insecticides recommended for aphid control, their chemical class and mode of action, product use rate, and limit to harvest or other restrictions. The materials recommended are generally safer to both people and aphid predators and parasites, thus should preserve as much biological control as possible. They do not tend to agitate aphids so movement is minimized. Table 3 contains information on control of other insects. Growers should pay attention to potato psyllid the vector of zebra chip disease when selecting foliar insecticides for aphid control.

Table 1. Mineral Oils

Some Common Petroleum-based High Paraffinic Mineral Oils	Rate	Notes
Aphoil	1-6 qts. depending on product. See Label.	Mineral crop oils do not control aphids but will reduce transmission and acquisition of stylet-borne viruses like PVY and PVA. Coverage is critical, therefore higher volumes, higher pressures and a 5-7 day spray schedule are needed to ensure coverage of foliage. These products can be used with conventional insecticides and fungicides- **CHECK THE LABEL. Do not use with TPTH or copper-based fungicides** Most labels have a 4 hr. reentry period.
Glacier Spray Fluid		
JMS Stylet Oil		
Organic Leaf oil		
PureSpray		
Seasons Spray Oil		
Sunco Sunspray		
Superior 70		
Ultra- Fine		
Vazyl-Y		

Following roguing, plants must be removed from the field. Improperly disposed, infected vines can regrow and become an additional source of virus inoculum in the field.
Photo: Nina Zidack

Table 2. Insecticides recommended for aphid control foliar application for seed potatoes in Montana, their chemical class and mode of action, product use rate, and limit to harvest or other restrictions.

Insecticide (common name) RUP=Restricted Use Pesticide	Class IRAC Group	Product/A	Restrictions (PHI=pre-harvest interval), re-entry period
Assail 30 SG Assail 70 WP (acetamiprid)	N 4A N	1.5-4.0 oz. 1.0-1.7 oz.	Higher rate is suggested, no more than 4 applications per season, do not apply more than once in 7 days. 7 day PHI. Through coverage is critical. Use MSO. COC or organosilicone adjuvant, not spreader/sticker type adjuvant-12 hr. re-entry without PPE
Athena-RUP Avermectin+ bifenthrin	P3+ B1	7-17 fl. oz.	21 day PHI. 12 hr. re-entry without PPE
Brigadier, Swagger RUP (bifenthrin+imidacloprid)	P- 3+N-4A	4.8-6.14 oz.	Do not make applications < 7 days apart, 21 day PHI. Use < 25.6 fl. oz. per season. Use adjuvant such as MSO, NIS or COC. 12 hr. re-entry without PPE
Hero RUP (bifenthrin+ zetacypermetrin)	P3	4.0-10.3 oz.	21 day PHI, Maximum 0.2 lb/A/season. 12 hr. re-entry without PPE
Fulfill (pymetrozine)	SFB 9B	2.75-5.5 oz.	Use < 11oz/season, allow 7days between applications, 14 day PHI. This material stops aphid feeding. Translaminar movement so spray is rainfast as soon as it is dry. 12 hr. reentry without PPE
Belay 2.13SC (clothianidin)	N 4A	1.9-2.8 oz.	Use < 8.4 oz per season, allow 7 days between applications, 14 day PHI. 12 hr. re-entry without PPE

Table 2 cont.

Insecticide (common name) RUP=Restricted Use Pesticide	Class IRAC Group	Product/A	Restrictions (PHI=pre-harvest interval), re-entry period
Beleaf (flonicamid)	PC - 9C	1.2-2.8 fl. oz.	Higher rates are suggested. Up to 14 days residual control. Use < 8.4 fl. oz. or 3 applications per season. 7 day PHI. 12 hr. re-entry without PPE
Impulse 1.6 FL, Nuprid 1.6 F, Pasada 1.6 F, Prey 1.6, Sherpa, Advise 2FL, Couraze 2F, Macho 2FL, Montana 2F Nuprid 4F Max, Wangler, Provado 1.6 F (imidacloprid)	N 4A	3.0-3.8 fl. oz.	Use < 16 fl. oz. per season, observe plant back restrictions, 7 day PHI, check product label for rate. 12 hr re-entry without PPE
Vydate L RUP oxamyl	1A	2-4 pt.	Limit to 6 applications/ season-7 day PHI. 48 hr. re-entry without PPE
Leverage 2.7 RUP (imidacloprid+ cyfluthrin)	N4A+ P-3	3.8 fl. oz.	7 day PHI. 12 hr. re-entry without PPE
Movento (spirotetramat)	LBI 23	4.0-5.0 fl. oz.	7 day PHI, 7 day minimum interval, maximum 10 oz./season. 24 hr. re-entry without PPE
Actara (thiamethoxam)	N4A	3 fl. oz.	Use < 6 oz. per season, 14 day PHI, may need two applications at 7-10 day intervals. 12 hr. re-entry without PPE
Venom 20 SG (dinotefuran)	N4A	0.33 lb.	7 day PHI- no not exceed 0.99lb/A /season. 12 hr. re-entry without PPE
Voliam Flexi (thiamethoxam +chlorantaniliprole)	N4A+ D-28	4 oz.	Use < 8 oz. per season, > 7days between applications, 14 day PHI. 12 hr. re-entry without PPE
Voliam Express RUP Besiege (chlorantaniliprole+ lambda-cyhalothrin)	D- 28+P3	5-9 fl. oz.	<27 fl. oz. A/season. 14 day PHI, 24 hr. re-entry without PPE

Table 2 cont.

Insecticide (common name) RUP=Restricted Use Pesticide	**Class IRAC Group**	**Product/A**	**Restrictions (PHI=pre-harvest interval), re-entry period**
Endigo ZC RUP (thiamethoxam+ lambda-cyhalothrin)	N4A+ P-3	4-4.5 fl. oz.	Use < 10 fl. oz. per season, 14 day PHI. 24 hr. re-entry without PPE
Monitor 4L RUP (O,S-Dimethyl phosphoramidothioate)	OP-1B	1.5-2.0 pts.	14 day PHI-while very effective may cause surviving aphids to move, thus resulting in greater virus spread. Restricted Use Pesticide. 4 days re-entry without PPE
Sivanto (flypyradifurone)	N4 D	7-10.5 oz.	7 day PHI, 7 day interval, 12 hr. re-entry, 28 oz./season
Transform (sulfoxaflor)	N4C	0.075-1.5 oz.	7 day PHI, 24 re-entry, no more than 4 applications or 8.5 oz. per season. Consider this a neonicotinoid and rotate use with other mode of action.
Torac (tolfenpyrad)	21 A	17-21 oz.	14 day PHI, 14 day retreatment interval, 2 applications/season-12 hr. re-entry.
Requiem (extract of Chenopodium ambrosioides)		2-3 qts.	0, 4 hrs.
Synthetic Pyrethrins all RUP			**Note aphid populations maybe resistant**
Renounce 20 WP, Tombstone, Tombstone Helios (cyfluthrin)	P3A	0.8-3.5 oz.	0, 12 hr. re-entry without PPE
Baythroid (*beta-cyfluthrin*)	P3A	2.8 fl. oz.	0, 12 hrs. without PPE

Table 2. cont.

Insecticide (common name) RUP=Restricted Use Pesticide	Class IRAC Group	Product/A	Restrictions (PHI=pre-harvest interval), re-entry period
Asana XL, Adjourn (*esfenvalerate*)	P 3A	5.8-9.6 fl. oz.	Do not exceed 0.35 lb. ai./A per season. 7 day PHI. 12 hr. re-entry without PPE
Delta Gold, Battalion (*deltamethrin*)	P3A	1-17.9 fl. oz.	See product label for rate. 3 day PHI, 12 h.r reentry without PPE
Warrior with Zeon Technology (lambda-cyhalothin)	P3A	2.56-3.84 fl.oz	7 days, 24 hr.
Ambush, Pounce, Artic, Permastar, Permethrin, Perm-Up (permethrin)	P3A	0.1-0.2 lb.	See product label for rate. 14 day PHI. 12 hr. re-entry without PPE
Mustang Max, Respect (*Zeta-cypermethrin*)	P3A	1.28-4 fl. oz.	Aphid suppression only. 1 day PHI. 12 hr. re-entry without PPE

1. N= neonicotinoid, P=pyrethroid, PC=pyridine carboxamide, OP= organophosphate, D=diamide, LBI=Lipid biosynthesis inhibitor, SFB=selective feeding blocker
2. PPE= personal protective equipment- see label for specific requirement

Table 3. Some insecticides (trade/*common name)* registered for potato effects on insect pest other than aphid.

Insecticide RUP [1] (Active ingredient)	**Cabbage looper**	**Colorado potato beetle**	**Flea beetle**	**Potato leafhopper**	**Potato psyllid**	**Variegated cutworm**	**White grub**	**wireworm**
ABBA, Agri-Mek, Nufarm abamectin, Reaper, Temprano, Timectin RUP (Abamectin)		x[2]			x eggs, nymph, and adults			
Asana XL, Adjourn RUP (Esfenvalerate)								
Assail 30 SG, Assail 70 WP (Acetamiprid)		x	x	x				
Athena RUP (Avermectin+ Bifenthrin)	x	x	x	x	x eggs, nymph, and adults	x		
Belay 2.13SC (Clothianidin)		x	x	x	x			
Bifenture, Brigade, Fanfare, Sniper, Tundra RUP (Bifenthrin)			x				x at plant	x at plant
Brigadier, Swagger RUP (Bifenthrin+ Imidacloprid)		x	x	x	x		x at plant	x at plant
Baythroid XL RUP (Beta-Cyfluthrin)	x	x	x	x	x	x		
Beleaf (Flonicamid)					x nymph and adults			
Hero RUP (Bifenthrin+ Zetacypermetrin)	x	x	x	x		x		
Voliam Flexi (Thiamethoxam +Chlorantaniliprole)	x	x	x	x				

1. Restricted Used Pesticide 2. X= effective

Table 3 cont.

Insecticide RUP (Active ingredient)	Cabbage looper	Colorado potato beetle	Flea beetle	Potato leafhopper	Potato psyllid	Variegated cutworm	White grub	wireworm
Voliam Express, Besiege- RUP (Chlorantaniliprole+ Lambda-cyhalothrin)	x	x	x	x	x			
Fulfill (Pymetrozine)					x nymph and adults			
Impulse 1.6 FL, Nuprid 1.6 F, Pasada 1.6 F, Prey 1.6, Sherpa, Advise 2FL, Couraze 2F, Macho 2FL, Montana 2F Nuprid 4F Max, Wangler, Provado 1.6 F (Imidacloprid)		x	x	x	x			applied as seed treatments or at plant X
Leverage 2.7, 360 RUP (Imidacloprid+ Cyfluthrin)	x	x	x	x	x			
Regent (Fipronil)								x
Transform (Sulfoxaflor)	x	x		x	x	x		
Actara , Cruiser, Platinum thiamethoxam		x	x	x	Cruiser and Platinum X			Cruiser and Platinum X
Movento (spirotetramat)					X eggs, nymphs			
Requiem (Extract of *Chenopodium ambrosioides*)					x			
Venom 20 SG (Dinotefuran)		x	x	x	x			
Endigo ZC RUP (Thiamethoxam+ Lambda-cyhalothrin	x	x	x	x	x			

Note: Spinosad- Blackhawk is an excellent flea beetle material that will have minimal effects on predators and parasites.