Potato virus Y and Seed Health

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2022 Miller Research Program

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My background

- Crapo Farms summers during school
- Stukenholtz consulting summers during school
- Oregon State Univ. PhD 1993
- Seed certification Colorado 4 yrs
- Seed certification Idaho 6 years
- USDA pathologist on breeding program 18 yrs+



Prior to 2000 Before PVY: Leafroll and visual inspections – Oceanside, CA





Virus basics

Common Potato Viruses

Potato Virus Y

- Potato Virus A
- Potato Virus M
- Potato Virus S
- Potato Virus X
- Alfalfa Mosaic Virus =
 - (aka Calico Virus)
- Potato Leafroll Virus = PLRV



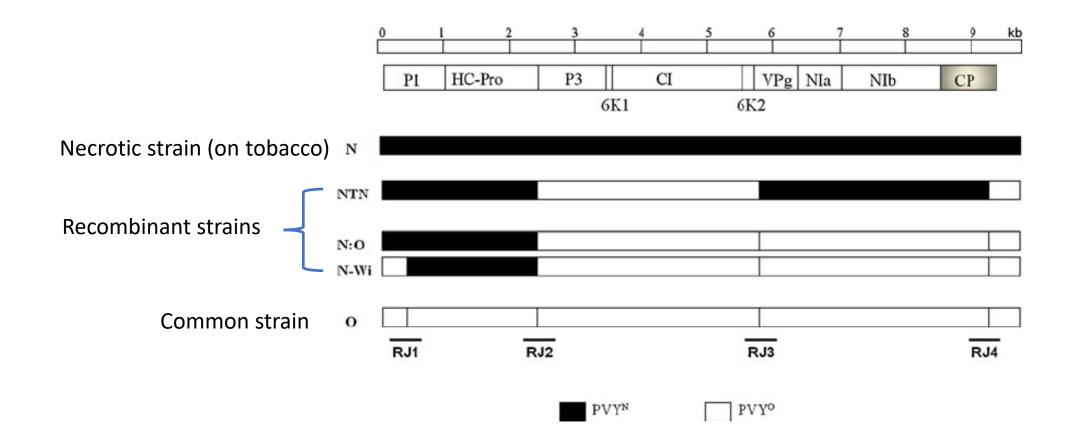
<u>Virus basics</u> Common Potato Viruses



Mosaic Virus

Make up of PVY strains

- *Potato virus Y* is a single strand RNA virus that is relatively ٠ short •
 - PVY has ~9700 base pairs and has a tendency to mutate



Karasev and Gray, 2013

Virus RISK to growers

1 PVVV (ubiquitous, vector is aphids, no insecticide control, 37-50% of the isolates

tested cause tuber damage in Yukon Gold.)

2. PMTV (vector is powdery scab, widely distributed)

- 3. TRV (vectored by stubby root nematode, limited distribution, but can be confused with PMTV)
- 4. **PLRV** (controlled by neonicotinoid insecticides)
- 5. AMV (at issue mostly when seed is grown next to alfalfa fields)
- 6. TSWV (can be a problem for greenhouse growers)

History of PVY and change in strains

- Prior to the early 2000s in the US and Canada, the primary strain was $\ensuremath{\text{PVY}^{\text{O}}}$
- PVY^O caused yield loss
- Necrotic strains can cause quality defects in tubers
- Necrotic strains such as PVY^{NTN} and PVY^{Nwi} have become more common place depending on the area of the country
 - The west has more $\mathsf{PVY}^{\mathsf{Nwi}}$ and the northeast has more $\mathsf{PVY}^{\mathsf{NTN}}$
 - PVY^O has been mostly replaced by the necrotic strains
- Certification keeps a list of varieties that have poor PVY expression

PVY – quick facts

- Aphids (non-persistent transmission)
- <u>Quality loss (necrotic tuber symptoms)</u>
- Foliar symptoms cause <u>yield reduction</u>
- Hosts are potato and nightshade weeds



PTNRD = Potato Tuber Necrotic Ringspot Disease

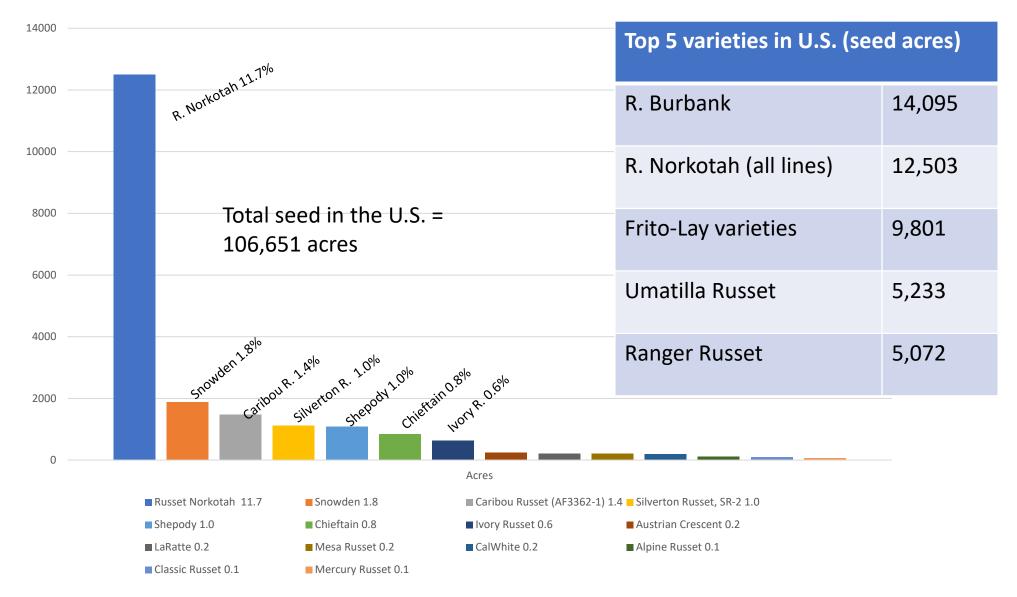
Alturas

Varieties with latent PVY symptoms (i.e. hard to see)

VARIETIES	STATES reporting	VARIETIES	STATES reporting
Alpine Russet	ND, MT	Ivory Russet	MT
Austrian Crescent	WA	Keystone Russet	СО
Banana	CO, OR, WA	LaRatte	CO, WA
Blazer Russet	ID, OR, ME, MT	Mesa Russet	СО
CalWhite	CA, ID, OR, WA	Mercury Russet	WI
Caribou Russet (AF3362-1)	ME, WI, MT	Pike	OR (specific strains)
Chieftain	WA	Purple Peruvian	CO, WA
Chipeta	CO	Rose Finn Apple	CO, WA
Classic Russet	OR, MT	Russet Norkotah	CO, ID, ME, MI, MN, ND, NE, NY, OR, WI, WA, ME, MT
Crestone Russet	CO	Sage Russet	OR
Dakota Diamond	NE	Shasta	OR
Easton	ME	Shepody	CO, ID, MI, MN, ND, NE, OR, WA, ME
French Fingerling	CO, WA	Silverton Russet, SR-2	CO, WI, ND, ID
Gem Russet	CO, OR, ID, ND, ME	Snowden	ME, WI
GemStar Russet	OR, ID	Winema	OR
Green Mountain	NY		
Innovator	CO, NY, ME		

(from U.S. seed certification agencies, 2021)

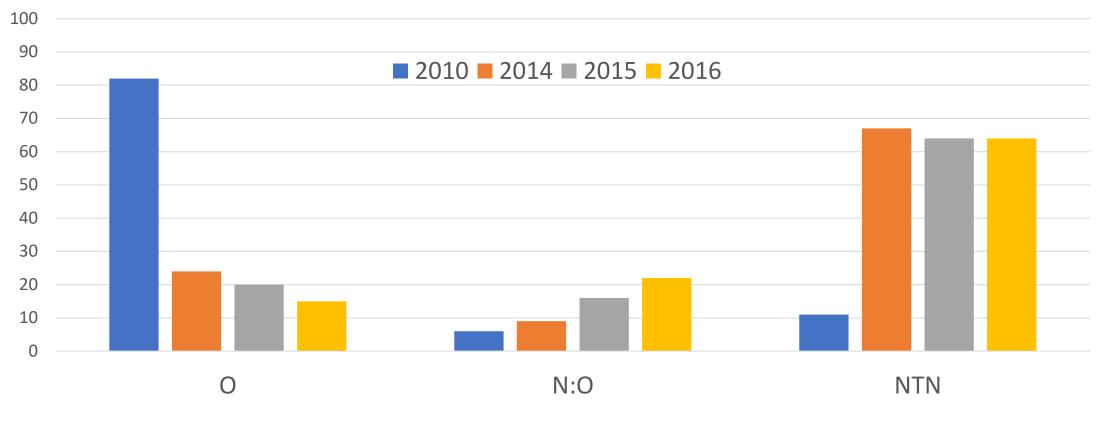
2021 Seed acres and % of total U.S. seed acres



PVY Strains at Othello, WA 100 90 ■ 2011 ■ 2012 ■ 2013 ■ 2014 ■ 2015 80 70 2021 N-Wi=78% 60 N:O=2% 50 2021 O=none 40 2021 NTN=20% 30 20 10 0 N:O/N-WI 0 NTN

Funke et al. 2017

PVY Strains at New Brunswick, Canada

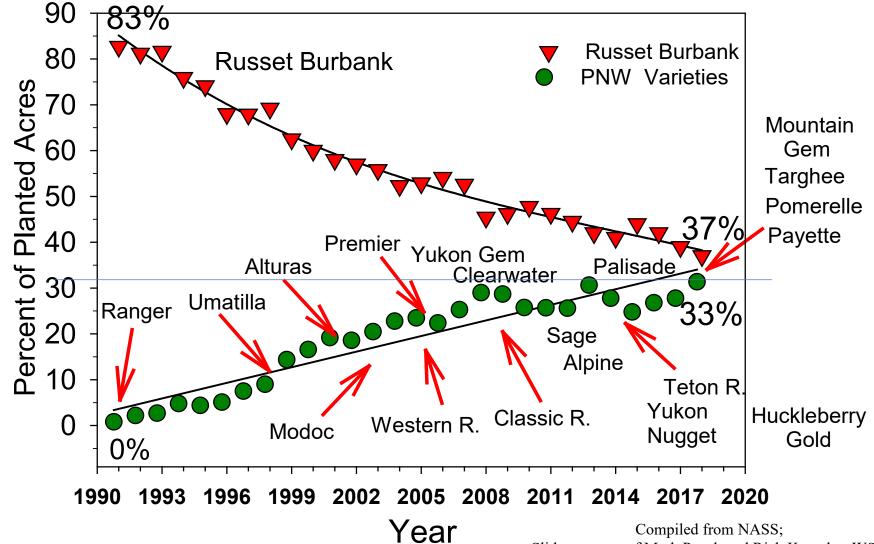


MacKenzie et al. 2018

How did this happen?

- Some ideas
 - Over years seed growers have been very good at removing virus through rogueing
 - The biology of the necrotic strains <u>may</u> be different allowing better transmission over the PVY^o strain
 - There has been a change in the varieties over the years and some do not show PVY symptoms very well

Impact of Tri-State Potato Varieties on PNW Production



Compiled from NASS

Slide courtesy of Mark Pavek and Rick Knowles, WSU

Potato Virus Y Demo 42 Varieties, 2 Planting Dates Healthy plants and 3 strains of PVY: PVYRO PVY N:O PVY N:O PVY NTN

WASHINGTON STATE Polate Research Group

PVYO

HEALTHY

(photos: Stewart Gray, Jonathan Whitworth, Mark Pavek)

PVY N:O

PVY NTN

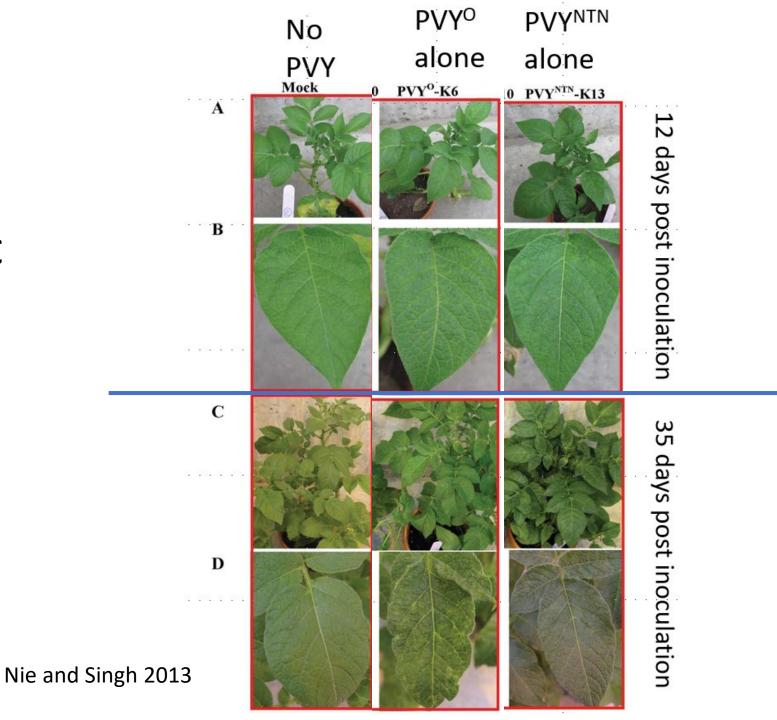








PVY mosaic symptoms

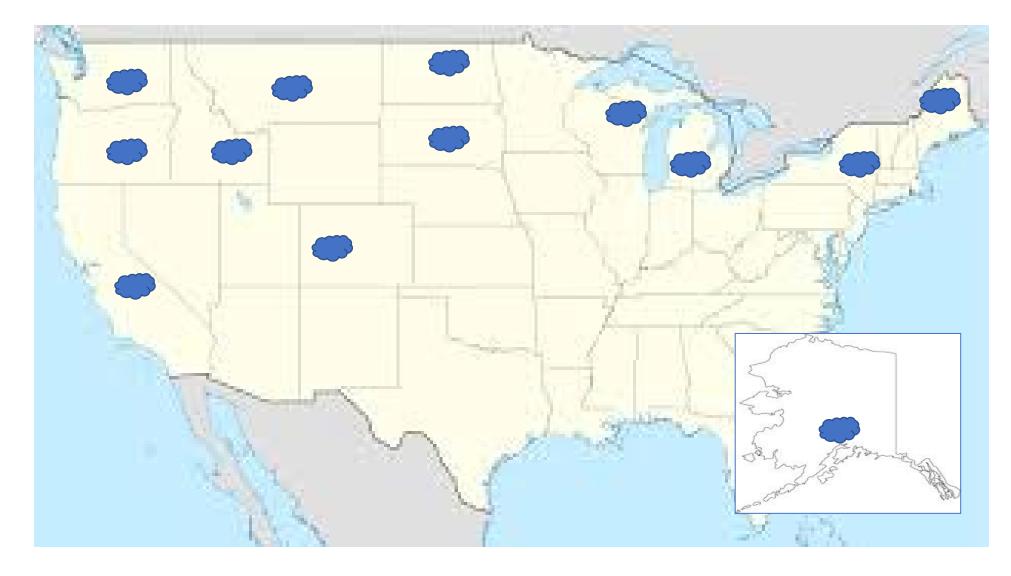


What is the risk to growers??

Test multiple varieties and market class reaction to PVY

- Combined work
 - Whitworth Lab Aberdeen, Idaho
 - Gray Lab Ithaca, New York
- Multiple varieties by class
 - Russet
 - Chip
 - Specialty
 - Reds
- Multiple PVY strains using multiple isolates
 - O, N:O, NTN, Nwi, NE-11

Origins of PVY isolates tested



Russet types foliar symptoms

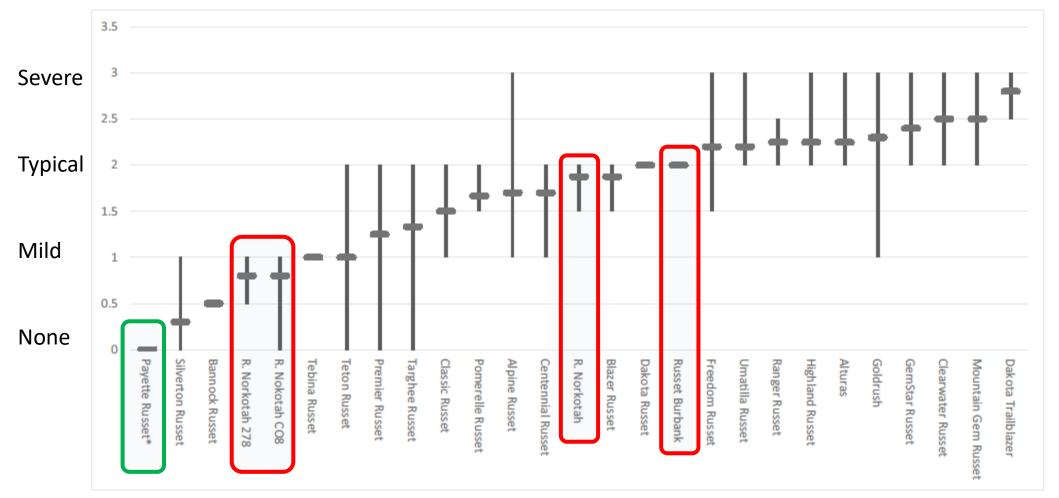


Fig. 4 Twenty-seven russet varieties foliar reactions for PVY. Scores are shown as an overall average, minimum and maximum of symptoms associated with multiple strains and isolates of PVY. Scores are based

on 0=no symptoms, 1=mild, 2=moderate, 3=severe. * Payette Russet is resistant - no virus detected



Potato virus Y necrotic tuber symptoms in varieties from different market classes



Jonathan Whitworth, USDA-ARS, Aberdeen, Idaho § Stewart Gray, USDA-ARS, Ithaca, New York Alex Karasev, University of Idaho, Moscow, Idaho § Corresponding author jonathan whitworth@usda.gov. associated paper Whitworth et al. 2021(Am. J. Potato Research 98:93-103)

Strains of Potato virus Y (PVY) can damage tubers and make them unmarketable. The composition of strains has changed since the early 2000s, when damaging strains were found in Canada and the U.S. Now, PVYNTN has become the predominant strain in eastern Canada, and PVYNW has become predominant in the Pacific Northwest. Not all PVY susceptible varieties show these symptoms, so this study was done to look at many varieties in different market classes to assess risk for tuber damage. Tuber damage is mostly associated with PVYNTN, but this research shows that PVYNW, PVYN:0, and PVY^o isolates also cause tuber damage.

BACKGROUND

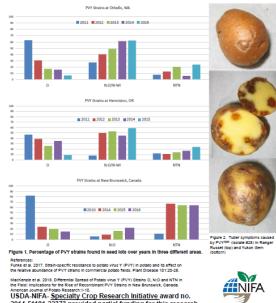
PVY causes yield reduction and some isolates can cause tuber damage, known as Potato Tuber Ringspot Disease or PTNRD. This damage can make tubers unmarketable. PVY isolates can be grouped into different strains based on their genetic makeup. There are some general characteristics to each strain such as the N (or necrotic) strains show a more mild foliar mosaid expression than PVY^O. While a number of strains have been identified, the most widespread in the U.S. are PVY⁰, PVY^{N:0}, PVY^{NM}, and PVY^{NTN}. SURVEYS

In the northwest U.S., surveys done in seed lot comparison trials show that over time, the PVY^O strain has decreased and mostly been replaced by PVY^{NM} in trials done at Othello, WA and Hermiston, OR. These trials contain samples of seed lots planted by commercial growers in Washington and Oregon. The samples represent seed lots from many different states, but the majority of them produced on seed farms in the northwest and western Canada (Funke et al. 2017)

In eastern Canada, surveys of commercial fields from 2010 to 2016 has shown a similar downward trend for PVY⁰ and an increase in PVY^{NTN} instead of PVY^{Nul} (MacKenzie et al. 2018). PVY COMPOSITION

PVY strains in the surveys come from two different parent sources. Recombinant strains come from an N strain and an O strain. NTN stands for "Necrotic-Tuber necrosis". N:O strands for a combination between strains N and O. N-Wi was named for necrotic-Wilga strain first found in Poland. Early surveys didn't make distinctions between N:O and N-Wi as the strains become more similar past the 2390 bp region. They may have also been reported together based on observations that these recombinants didn't cause PTNRD and the NTN recombinant did. This report shows that PTNRD can be associated with at least four strains; O, N:O, N-Wi, NTN. SYMPTOMS

Not all varieties express PTNRD. Greenhouse screenings of primary infections and examination of the daughter tubers was done on 66 varieties and using multiple PVY strains and isolates. PTNRD was evident in 18 varieties. Of those, 8 had tuber symptoms associated with NTN, 8 had tuber symptoms with N:O, 13 had tuber symptoms with N-Wi, and 11 had tuber symptoms with O (Table 1).



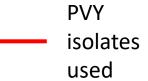
2014-51181-22373 provided partial funding for this research.

Table 1. Necrotic tu	ıber symptoms in po s. Multiple PVY isola	tato varieties groupe	d by PVY strain and				
PVY ^o		PVY ^{N:0}	PVY strain PVYN-Wi				
	tic tuber symptoms – from i						
		RUSSET	RUSSET				
Classic Russet	Highland Russet	Alturas	Alturas				
Highland Russet	Ranger Russet	Highland Russet	Centennial R.				
Ranger Russet	Russet Burbank Bannock Russet	Ranger Russet Russet Burbank	GemStar Russet Highland Russet				
CHIP Marcy	CHIP	CHIP	Ranger Russet				
Waneta	Chippewa	Chippewa	CHIP				
Pike	Pike	Pike	Pike				
Chippewa SPECIALTY/WHITE	Waneta	SPECIALTY/WHITE	Nicolet				
SPECIALTY/WHITE Katahdin	SPECIALTY/WHITE Yukon Gem	Yukon Gem Yukon Gold	Dakota Crisp SPECIALTY/WHITE				
Yukon Gem	Yukon Gold	Takon Gold	Red Thumb				
Yukon Gold			Russian Banana				
			Yukon Gem				
			Yukon Gold				
	NO PTNRD - no	tuber symptoms					
RUSSET	RUSSET	RUSSET	RUSSET				
Alpine Russet Alturas	Alpine Russet Alturas	Alpine Russet Alturas	Alpine Russet Alturas				
Bannock Russet	Bannock Russet	Bannock Russet	Bannock Russet (nt)				
Blazer Russet Centennial Russet	Blazer Russet	Blazer Russet	Blazer Russet Centennial Russet				
Centennial Russet Classic Russet	Centennial Russet Classic Russet	Centennial Russet Classic Russet	Centennial Russet Classic Russet (nt)				
Clearwater Russet	Classic Russet Clearwater Russet	Cleanwater Russet	Clearwater Russet (nt)				
Dakota Russet	Dakota Russet	Dakota Russet	Dakota Russet				
Dakota Trailblazer Freedom Russet	Dakota Trailblazer Freedom Russet	Dakota Trailblazer Freedom Russet	Dakota Trailblazer Freedom Russet				
Freedom Russet GemStar Russet	Freedom Russet GemStar Russet	Freedom Russet GemStar Russet	Freedom Russet GemStar Russet				
Goldrush	Goldrush		Goldrush				
Mountain Gem Russet	Mountain Gem Russet	Goldrush Highland Russet Mountain Gem Russet (nt) ² Payette Russet ¹	Mountain Gem Russet				
Payette Russet ¹ Pomerelle Russet	Mountain Gem Russet Payette Russet ¹ Pomerelle Russet	Pavette Russet ¹	Payette Russet ¹ Pomerelle Russet				
Premier Russet	Premier Russet	Pomerelle kusset (nt)	Premier Russet				
R. Norkotah COS B. Norkotah	R. Norkotah COB R. Norkotah	Premier Russet B. Norkotab CDS	R. Norkotah COS R. Norkotah				
R. Norkotah R. Norkotah 278	R. Norkotah R. Norkotah 278	R. Norkotah CDS R. Norkotah	R. Norkotah R. Norkotah 278				
Russet Burbank	Russet Burbank	R. Norkotah 278	Russet Burbank				
Silverton Russet	Silverton Russet	Russet Burbank	Silverton Russet				
Targhee Russet Tebina Russet	Targhee Russet Tebina Russet	Silverton Russet	Targhee Russet (nt) Tebina Russet (nt)				
Teton Russet	Teton Russet	Targhee Russet Tebina Russet (nt)	Teton Russet (nt)				
Umatilla Russet	Umatilla Russet	Teton Russet	Umatilla Russet (nt)				
<u>RED</u> Chieftain	<u>RED</u> Chieftain	Umatilla Russet <u>RED</u>	RED Chieftain (nt)				
Ciklamen	Ciklamen	Chieftain	Ciklamen				
Colorado Rose	Colorado Rose	Ciklamen	Colorado Rose Dakota Jewell				
Dakota Jewell Dakota Ruby	Dakota Jewell Dakota Ruby	Colorado Rose Dakota Jewell	Dakota Jewell Dakota Ruby				
Desiree	Desiree	Dakota Ruby	Desiree				
Modoc	Modoc	Desiree	Modoc				
Red Endeavor Red Gold	Red Endeavor Red Gold	Modoc Red Endeavor	Red Endeavor Red Gold				
Red Gold Red LaSoda	Red LaSoda	Red Endeavor Red Gold	Red LaSoda				
Red Norland	Red Norland	Red LaSoda	Red Norland				
Rio Colorado CHIP	Rio Colorado	Red Norland Rio Colorado	Rio Colorado				
Andover	CHIP Andover	CHIP	CHIP Andover				
Atlantic	Atlantic	Andouer	Atlantic				
Chipeta Dakota Crisp	Chipeta Dakota Crisp	Atlantic Chipeta	Chipeta Chippewa				
Dakota Crisp Eval	Dakota Crisp Eva ¹		Chippewa Dakota Crisp				
Kennebec	Kennebec	Dakota Crisp	Eval				
Lamoka	Lamoka	Evo ³	Kennebec				
Megachip Nicolet	Marcy Merachio	Kennebec Lamoka	Lamoka Mezachio (nt)				
Pinnacle	Megachip Nicolet	Megachip	Megachip (nt) Marcy				
Snowden	Pike	Marcy Nicolet	Nicolet				
Superior Waneta	Pinnacle Snowden	Nicolet Pike	Pike Pinnacle				
SPECIALTY/WHITE	Superior	Pinnacle	Snowden				
Bintje Calwhite	SPECIALTY/WHITE	Snowden	Superior				
Calwhite French Fingerling	Bintje Calwhite	Superior Waneta	Waneta SPECIALTY/WHITE				
Gala	French Fingerling	SPECIALTY/WHITE					
Oneida Gold	Gala	Bintie	Bintje Calwhite				
Red Thumb Russian Banana	Katahdin Oneida Gold	Calwhite French Fingerling	French Fingerling Gala				
Shepody Snowbird	Red Thumb	Gala	Katahdin				
Snowbird	Russian Banana	Katahdin	Oneida Gold				
	Shepody Snowbird	Oneida Gold Bed Thumb	Shepody Snowbird				
		Red Thumb Russian Banana	SHOWER'S				
		Shepody					
		Snowbird					
ISOLATES USED FOR PVY SO	REENINGS - MANUAL INOCI	ULATIONS - isolates in BOLD	produced PTNRD*				
Waneta, Yeem, Wold)	#5 (Bannock, Chippewa.	Yeold)	#14 (Pike, Ygold)				
#18 (Marcy, Pike, Waneta,	Highland, Ranger, Ygern, Ygold)	#4 (Chippewa)	#28 (Alturas, Highland, Ranger,				
Ygold) #33 (Chiopean Checks	#10 (Pike, Waneta, Ygern, Yanid)	#8 (R. Burbank) #9 (Renser)	Ygern, Ygold) #29 (Centennial P. Dalaste				
Highland, Ranger, Ygern, Ygold)	XEETINGS - MANUAL INCO #1 (Ygold) #6 (Bannock, Chippewa, Highland, Ranger, Ygem, Ygold) #10 (Pike, Waneta, Ygem, Ygold) #16 (Ranger, R. Burbank, Ygold) #19 (Ygold) #19 (Ygold)	ULATIONS - isolates in BOLE #2 (Alturus, Highland, Ygent, Ygeld) #4 (Chipperwa) #8 (R. Burbank) #0 (Ranger) #11 (Chipperwa, Ygold) #22 (Ygold) #23 (Ygold) #37 (Pipe Yould)	Crisp, GemStar Russet, Nicolet,				
#31 (Marcy, Pike, Ygold)	#19 (Ygold)	#22 (Ygem)	Red Thumb, Russian Banana,				
#2 (no PTNPD)	#19 (Ygold) #24 (Waneta, Ygold) #30 (Highland, Ranger, Ygem,	#22 (Ygem) #23 (Ygold) #37 (Pike, Ygold)					
#25 (no PTNRD) #27 (no PTNRD)	Ygold)		#12 (no PTNRD)				
#27 (no PINKD)	+30 (ngmand, nanger, ngen, Ygold) #32 (Chippewa, Highland, Ygem, Ygold) #34 (Ygold)	#17 (no PTNRD) #36 (no PTNRD)					
	#34 (Ygold)						
1 Eva and Payette Russet have extreme resistance to PVY. Extreme resistance is defined as resistance to all strains of PVY. These							
varieties did not become infecte	d after inoculation with these list	ed isolates of PVY.	1 Eva and Payette Russet have extreme resistance to PVY. Extreme resistance is defined as resistance to all strains of PVY. These varieties did not become infected after inoculation with these listed locates of PVY. 2 (citr) not tasket				
2 (et) not tested		2 (nt)- not tested 3 for isolate names, including available genbank accession numbers, contact <u>ionathan whitworthi@usda.gov</u>					
2 (nt)- not tested 3 for isolate names, including av	ailable genbank accession numbe	rrs, contact <u>ionathan whi</u> tworthid	Pusda.gov				

Varieties with tuber symptoms

Varieties NO tuber symptoms

Poster available – email me at Jonathan.Whitworth@ usda.gov



What about PTNRD in tubers?

Table 1. Necrotic tuber symptoms in potato varieties grouped by PVY strain and variety market class. Multiple PVY isolates were used for each PVY strain

ΡVΥ ^ο	Ρνγντν	ΡVY ^{N:O}	PVY ^{N-Wi}			
PTNRD – necrotic tuber symptoms – from at least one isolate of the above PVY strains						
<u>RUSSET</u>	<u>RUSSET</u>	<u>RUSSET</u>	<u>RUSSET</u>			
Classic Russet	Highland Russet	Alturas	Alturas			
Highland Russet	Ranger Russet	Highland Russet	Centennial R.			
Ranger Russet	Russet Burbank	Ranger Russet	GemStar Russet			
	Bannock Russet	Russet Burbank	Highland Russet			
			Ranger Russet			
<u>CHIP</u>	<u>CHIP</u>	<u>CHIP</u>	<u>CHIP</u>			
Marcy	Chippewa	Chippewa	Pike			
Waneta	Pike	Pike	Nicolet			
Pike	Waneta		Dakota Crisp			
Chippewa			SPECIALTY/WHITE			
SPECIALTY/WHITE	SPECIALTY/WHITE	SPECIALTY/WHITE	Red Thumb			
Katahdin	Yukon Gem	Yukon Gem	Russian Banana			
Yukon Gem	Yukon Gold	Yukon Gold	Yukon Gem			
Yukon Gold			Yukon Gold			

PVY isolates used for screening

Ρνγο	Ρνγ	PVY ^{N:O}	PVY ^{N-Wi}			
ISOLATES USED FOR PVY SCREENINGS - MANUAL INOCULATIONS – isolates in BOLD produced PTNRD ³						
 #5 (Katahdin, Marcy, Pike, Waneta, Ygem, Ygold) #18 (Marcy, Pike, Waneta, Ygold) #33 (Chippewa, Classic, Highland, Ranger, Ygem, Ygold) #31 (Marcy, Pike, Ygold) #3 (no PTNRD) #25 (no PTNRD) #27 (no PTNRD) 	<pre>#1 (Ygold) #6 (Bannock, Chippewa, Highland, Ranger, Ygem, Ygold) #10 (Pike, Waneta, Ygem, Ygold) #16 Ranger, R. Burbank, Ygold) #19 (Ygold) #24 (Waneta, Ygold) #30 (Highland, Ranger, Ygem, Ygold) #32 (Chippewa, Highland, Ygem, Ygold) #34 (Ygold)</pre>	<pre>#2 (Alturas, Highland, Ygem, Ygold) #4 (Chippewa) #8 (R. Burbank) #9 (Ranger) #11 (Chippewa, Ygold) #22 (Ygem) #23 (Ygold) #37 (Pike, Ygold) #17 (no PTNRD) #36 (no PTNRD)</pre>	<pre>#13 (Ygem) #14 (Pike, Ygold) #28 (Alturas, Highland, Ranger) Ygem, Ygold) #29 (Centennial R., Dakota Crisp, GemStar Russet, Nicolet, Red Thumb, Russian Banana, Ygold) #12 (no PTNRD)</pre>			

SCRI grant - Tuber Necrotic Viruses (<u>PVY, PMTV</u>)

- Alex Karasev leading
- Colorado
 - Charkowski, Nalam, Wilbur,
- Idaho
 - Duellman, Karasev, Kuhl, McIntosh,
 - Novy, Olsen, Wenninger, Whitworth
- Maine
 - Dill, Dwyer, Douches
- Montana
 - Zidack

- North Dakota
 - Pasche
- New York
 - De Jong
- Oregon
 - Frost
 - Sathuvali
- Washington
 - Feldman, Pavek, Swisher-Grimm
- Wisconsin
 - Groves, Rioux

How you can find out about a grower's seed

- All programs have records on each lot
- All growers receive copies of their inspections
- Visit the grower's farm and/or storage
- A phone call requesting inspection reports OR requesting a PLANT HEALTH CERTIFICATE



Seed Certification <u>can</u>:

- Detect PVY, PLRV, PVX
- Detect Bacterial Ring Rot (BRR)
- Detect blackleg
- Detect variety mixes
- Detect chemical damage
- Keep identity
 - Determine eligibility of seed for certification in the program
 - Do field inspections
 - Do storage inspections
 - Do shipping point inspections

Seed Certification can't (doesn't):

- Regulate (except under general tolerances of external and internal defects):
 - Tobacco rattle virus
 - Potato mop-top virus PMTV
 - Powdery scab
 - Common scab
- Use a tag to indicate disease status
 - Tags are used to indicate size and grade
 - Along with a few restrictions on appearance that can be caused by diseases.

Two types of tolerances (Idaho – other states similar)

- Field test (summer)
 - Seed borne infection
 - Tolerances
 - 0.2% PLRV
 - 1% 'Well Defined Mosaic'
 - 1% total virus
 - 0.2% variety mix
 - 0% Bact. Ring Rot

- Field or lab test (winter)
 - Current season infection
 - Tolerances
 - 0.8% PLRV
 - 1% 'Well Defined Mosaic' (for recertification)
 - 5% Chemical damage
 - 0% Bact. Ring Rot

Comparison between tolerances

- Summer Inspection
 - 200 plants/acre
 - in a 50 acre field, 1 positive plant = 0.01%
 - tells us about tuber borne virus



- 400 tubers/sample
- in a sample 1 positive plant = 0.25%
- tells us about current season spread of virus

THEREFORE, a winter inspection gives an INDICATION of the virus level



PVY yield drag (1% virus = 1.5 cwt decrease)

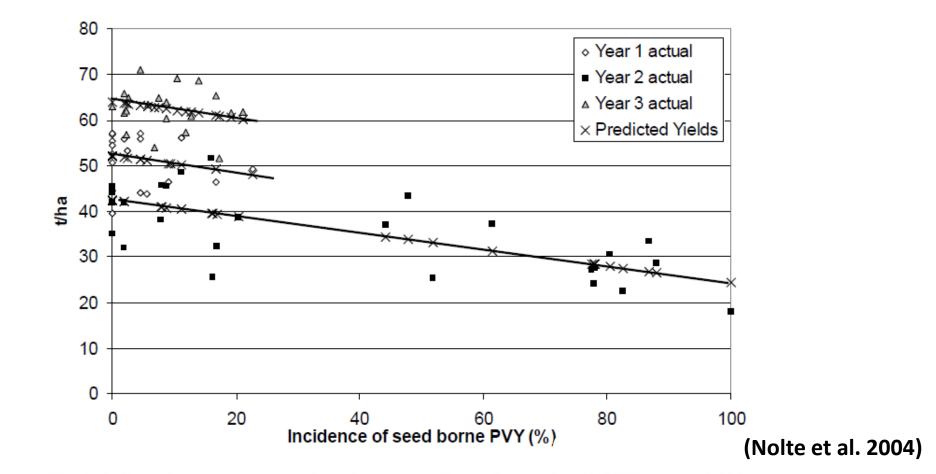


Fig. 1. Ordinary least squares regression of percent seedborne *Potato virus Y* (PVY) versus yield in tonnes/hectare (t/ha) for 3 years of replicated field trials in Russet Burbank potato. Predicted values

I bought blue tag seed, why do I have so much virus?

§51.3001 Grade.

"U.S. No. 1 Seed Potatoes" consist of unwash of origin by blue tags fixed to the containers of accompanying bulk loads, which identify the shipper of the potatoes, and the State certifica following requirements:

- (a) Fairly well shaped.
- (b) Free from:
- Freezing injury;
- (2) Blackheart;
- (3) Late Blight Tuber Rot;
- (4) Nematode or Tuber Moth injury;
- (5) Bacterial Ring Rot;
- (6) Soft rot or wet breakdown; and,
- (7) Fresh cuts or fresh broken-off second growth

A. Idaho Certified Blue Tag Seed Potatoes

The blue tag shall be equivalent to U.S. No. 1 seed potato grade with the following exceptions. There is a 1% tolerance for late blight.

- 1. Scab shall not cover more than one-fifth of the surface area.
- Adhering dirt a maximum of 50% of the tuber surface may be covered with caked dirt.
- 3. Loose dirt and/or foreign material included in total external tolerance.
- 4. Clipping or trimming not allowed.
- 5. Freshly broken off second growth shall not be damaged.

VIRUS?????



United States Department of Agriculture United States Standards

C.

§51.1543 U.S. No. 2.

"U.S. No. 2" consists of potatoes which (a) Similar varietal characteristics, exce

(b) Not seriously misshapen;

(c) Free from:

Freezing;

Blackheart;

(3) Late blight, southern bacterial wilt a

(4) Soft rot and wet breakdown.

(d) Free from serious damage by any ot

(e) Size. Not less than 1-1/2 inches in o the grade.

(f) For tolerances see §51.1546.

Idaho Certified Yellow Tag Seed Potatoes

The yellow tag grade shall be equivalent to the U.S. No. 2 grade with the following exceptions. There is a 1% tolerance for late blight.

- Maximum and minimum size shall be specified by the grower.
- 2. Wireworm and/or grub no requirements.
- Scab no requirements.
- Hollowheart no requirements.
- 5. Adhering dirt no requirements.
- 6. Loose dirt and/or foreign material included in total external tolerance.

VIRUS?????

STATE OF NEBRASKA INSPECTION AND BULK CERTIFICATE A5475 OF CERTIFIED SEED POTATOES

This certificate is issued pursuant to the authority vested in the Potato Certification Association of Nebraska, designated by the Institute of Agriculture and Natural Resources, University of Nebraska, under Sections 81-2, 149 to 81-2, 154, R.R.S., Nebraska, 1943. This certificate is valid only when signed by a person designated as an inspector. *Warning:* Every person, firm, association or corporation who shall falsely make, issue, forge, or counterfeit this certificate, or participate in any such actions shall be fined, upon conviction thereof, in any sum not less than \$100.00 nor exceeding \$500.00 for each offense.

		dress of Applicant	Carrier		Initial and Number		
SEED PUTATOE	s L		Rail Car TF 9418 IO Farm Truck Semi-trailer/w/aCX TF 2477 IO				
INSPECTI	ON BEGUN	INSPECTION	COMPLETED	INSPECTI	ON POINT		
Date	Hour	Date	Hour				
4-20-16	LOUAM	4-20-16	900 AM	PINEB	LUFFS		
Product:	Loader's Count and Container:	Crop Year: 2015	Size Range:	Nebraska	Conveyance:		
Seed Potatoes	73800	Variety:	1½ inches to 10 ounces	Certified Seed	Enclosed		
Round Yellow		RUSSET	1½ inches to 12 ounces	Potatoes	Refrigerated		
Round White	New bags@ 100 lbs net	NORFOTAIE	1½ inches to 14 ounces	Grade:	Semi-Trailer		
Round Red	New bags@ 50 lbs net	278	1¼ inches to 2 1/8 inches	Bitue Tag	Farm Truck		
Long White			(Size B)	Yellow Tag	Hopper Bottom		
Long Russet	Plastic Totes		Other:	Green Tag	Live Bottom		
	Grown By:				Tarp-Covered		
SEED POTATAE					(PUA)		

Quality and Condition:	Firm,	Slightly Flabby,	well-shaped,	fairly clean,	slightly dirty,	mature
Remarks:						

Field # 15 397 N G1 G2 G3 G4 G5 We, the undersigned submits that the potatoes covered by this CERTIFICATE, not to exceed the above weight, have been grown and handled

according to the rules and regulations governing the production of Certified and/or Foundation Seed Potatoces as promulgated by the Vice-Chancellor, Institute of Agriculture and Natural Resources, University of Nebraska administered by the Potato Certification Association of Nebraska.

Since the use, crop, yields or quality of Certified Seed Potatoes is beyond the control of the grower, seller, inspector, Potato Certification Association of Nebraska, or the Institute of Agriculture and Natural Resources, University of Nebraska, no warranty of any kind, expressed or implied, including merchantability, which extends beyond the description above is made concerning the performance or quality of the seed potatoes. By acceptance of these seed potatoes, the buyer expressly agrees that its exclusive remedy for breach of any warranty shall be limited in all events to a return of the purchase price of the seed. This Certificate identifies the above described seed potatoes as Certified only while they are on board the conveyance described above, and the seal remains unbroken. Once they are unloaded, no further identity with this Certificate may be claimed.

I, the undersigned, a duly authorized Potato Certification Inspector of the State of Nebraska, do hereby certify that on the date indicated I personally inspected the above described products and that quality and/or condition pertaining to said products were as herein stated.

Inspector

Inspection Fee	ОТ	Expenses	Total Fees
	210	A Starter Starting	

Seed Potato Idaho Crop I Member DAHO DISCLAIMER OF WARRANTY AND LIMITATION OF REMEDY AND LIA SINCE THE USE OF CERTIFIED SEED POTATOES IS BEYOND THE CONTROL THE GROWER, THE SELLER, THE INSPECTOR, THE IDAHD FEDERAL STATE THE UNIVER. THE SECLER. THE WORKSTOWN THE HUMPED AND FEDERAL STATE SPECIFIC SERVICE AND THE UNAND CORE IMPROVEMENT ASSOCIATION NO WARRANTY OF ANY KIND EXPRESS OR IMPLIED INCLUDING MERCHA BITTY FITNESS FOR A PARTICULAR PHENDER, QUALITY OF REPORT DISEASE, IS MADE CONCERNING THESE SPED PUTATOES WHICH EXT C BEYOND THE DESCRIPTION SET FORTH ABOV THE GROWER. THE SELLER. THE INSPECTOR. THE IDAI THE BOOVER, THE SELLER, THE INSPECTION THE MARRIESE AND A DATA SECTION SERVICE AND THE TRANSPORT INSPECTION SERVICE AND THE LIABLE VIEW OF MARY SPECIAL OF CHARTY NEGLICIENCE OF STRUCT LIABLITY FOR ANY SPECIAL OF CHARTY AND A DATA SERVICE AND THE AND A DATA SERVICE AND A DATA SER Π J TF Tags/ Certificates D SE R. BURBANK POTATOL Vasiety B DVX-GI Class 57416737 Certification No. POTATOES GRAND TETON Selas Grower 64830 Buyer's Name aho 83705 (Optional) 50,000165 T. (Approx.) 194196 No.

GROWER: SEED: 2015 Crop BULK TAG NO. 4737 RUSSET NORKOTAH TX(278) PVX Generation 2 - PVY Tested MONTANA CERTIFIED SEED POTATOES

Certification for seed shipped prior to the completion of post-harvest testing is limited to visual observations of field inspections and results of virus disease testing conducted during the growing season.

The grower is responsible for complying with the Rules and Regulations for the certification of seed potatoes. For a copy of the certification Rules and Regulations write to Seed Potato Certification, Montana State University-Bozeman, PO Box 172060, Bozeman, MT 59/17-2060. These seed potatoes have been subject to field and bin inspections by qualified inspectors and, at the time of inspection, met all requirements as set forth in the Rules and Regulations of Montana State University. All certified seed potatoes must be grade inspected at the time of delivery or acceptance and must meet the grade denoted by the tag color. Responsibility for grade shall rest with grower. This tag applies to lots grown in season as indicated, and may be used only on lots certified by the Montana State University.

"NOTICE TO BUYER: DISCLAIMER OF WARRANTY AND LIMITATION OF REMEDY AND DAMAGES" Certified seed potatoes have been subjected to field and bin inspections pursuant to Rules and Regulations of Montana State University. The selent, the inspector, Montana State University and any of its entities make NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED INCLUDING MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, QUALITY, OR ABSENCE OF DISEASE CONCERNING SAID SEED POTATOES. The certification tag pertaining to any certified seed potatoes indicates only that, at the time of inspection, the potatoes inspected met the requirements for certification as set forth in said Rules and Regulations. BY ACCEPTANCE OF THE SEED POTATOES, BUYER EXPRESSLY AGREES THAT ITS EXCLUSIVE REMEDY FOR ANY BREACH OF DUTY OWED IN REGARD TO CERTIFICATION SHALL BE LIMITED SOLELY AND EXCLUSIVELY TO A RETURN OF THE PURCHASE PRICE FAID BY BUYER FOR SAID SEED.

This disclaimer of warranty and limitation of liability and remedy may not be altered or amended except by an instrument in writing and then only as to those specifically and expressly agreeing to the terms of said agreement. By acceptance of the seed potatoes, buyer agrees that the disclaimer and limitations described herein are express conditions of sale, and that they constitute the entire agreement between the parties regarding warranty, liability or remody.

Seal No	C.11/22/2
Inspection Cert. N	
Date Inspected _	5/7/2016
Buyer Name	
Wt. (Approx.)	59,000 lbs
Date and Time L	oaded
Transportation Fi	rm
Driver's Initials	
Carrier License o	r Car No. IDTE 4171

NORTH AMERICAN CERTIFIER SEED ROTATO HEALTH CERTIFICATE CROP VEAR 2020

Name City, State/Prov. Variety 5 Acres 60.0000	Quantity Shipped Size Lot origination from tissue culture No Yes
Variety B Acres 60.0000	Size
Lot Certification	Size
Lot Certification	
	Let origination from ticque gulture
	Lot origination nom ussue culture into thes
	Year micropropagated for planting
Certification # Seed Class/Gen. FY4	by
Certifying State/Prov. ID Braduation environment padiaroot Fill 1 column per production year up	as different initials in Oreenhouse and Eield heves for different forms
	se different initials in Greenhouse and Field boxes for different farms
(e.g. JSF for John Smith Farms); indicate a tuber-united lot with a "+" after fa	
2019 2020	Year of Production
	Greenhouse (insect excluding) & sterile soil
X X	Field (note special measures below)
	Certification No.
MT	Certifying State
Summer Field Readings	Winter Grow-out Readings
Field inspections	
1st 2nd 3rd Final	Final Location Waialua, HI
0.0000 0.0000 0.0000 %LEAF ROLL	0.00%
0.0000 0.0000 0.0000 %MOSAIC	0.53% Sample No.
	Plant Count 380
Less Than 0.0000 %BLACKLEG	Post-harvest laboratory test results
Less Than %∨ERT + %FUSARIU	JM + %PVY %PLRV
%EARLY BLIGHT	
	BRR Test Results NEGATI
•	ars since last found grower's farm, or Not found this year during
Other Diseases Not known to occur in growers NONE ON	I RECORD if free > normal certification field
	5 years inspections
Bacterial Ring Rot NONE	ON RECORD
.ate Blight	
	X

Alan Westra/Area Manager

Program official/title

1/21/2021

Date

NORTH AMERICAN CERTIFIED SEED POTATO HEALTH CERTIFICATE - CROP YEAR 2020

Grower		,	Importer		
Name	l	l			
City, State/Prov		[
Variety	Acres 40.70		Size	Quantity Shipped	
Lot Certification Certification #	Lot origin	ation from t	issue culture	No Yes	XX
Seed Class/Gen. FY2				Year micropropagated for planting	2018
Certifying State/Prov Nebraska		by		CSS, CO	
Production environment pedigree: Fill 1 column pe (e.g. JSF for John Smith Farms); indicate a tuber-united le	er production year, us	e different initia n initials; descri	als in Greenhou ibe other footso	se and Field boxes for different farms ates in notes below.	
	2018	2019	2020	Year of Production	

2014	2015	2016	2017	2018	2019	2020	Teal of Production
		_					Greenhouse (insect excluding) & sterile soil
		-		FYO (greenhouse)	FY1	FY2	Field (note special measures below)
					19261	20319	Certification No. Number of years produced
				CO	NÊ	NE .	Certifying State in field soil 2
ield inspec	rield Rend tions 2nd NS NS	ard NS NS Loss Then Less Then	Final NS NS NS NS NS	%LEAF RO %MOSAI %VARIETAL M %BLACKL %VERT + %FUS/ %EARLY BL	C IXTURE EG ARIUM +	Post harves	Location PCAN Lab; Berea, NE Sample No. Plant Count 440 ELISA test results for latent viruses: Summer Winter %PVY 0.00% %PVY 0.009
Other Dis	eases		Not know	vn to occur in growers area	No. of year farm, or NO	s since last for NE ON RECO	und on this grower's Not found this year during normal DRD if free > 10 years certification field inspections
Bacterial R	ing Rot					None on R	lecord
Late Blight							x
			Eligible for	r recertification in area o	fproduction		Yes x No
Notes Summer la	aboratory to	ests for Cms	, PLRV, PVS	BRR tested on a 2000-t , PVX, PVM, PVA, and Pa	uber sample t tro on this lot and all were	were conduct	and found NEGATIVE. ted by the Potato Certification Association of Nebraska in Berea, I
* NŞ = None S	Seen (visua) ir	spection), NT	= No Test, PH	T = Post harvest lest, Tr = Tra	ce (<0.1%)		
The above i	information	is accurate	to the best	of our knowledge:			
Ada	nl	Ninc	hester	r		_	3-Mar-2021
Adam Wine	chester					-	Date
Data	to Cartifica	tion Associ	ation of Neb	raska			308.762.1674

Agency

Points to keep in mind while looking at seed lot testing results

- These are samples and samples represent what is in the total population
- There are always error levels built into sampling numbers and surveys
 - For example, people sometimes talk about a survey having a 5 point +/margin of error
- Every sample taken may have a slightly different results
 - Use the % as an indicator of HIGH, MEDIUM or LOW
 - IF A SEED LOT IS ABOVE 10% IT IS HIGH
 - IF A SEED LOT IS BELOW 10% IT IS MEDIUM OR LOW DEPENDING ON THE %

Slow down when making seed purchases.

Make sure you have all of the information!!

Bringing resistance into new varieties

- Most success in PVY resistance
 - Ry genes, dominantly inherited genes
 - Provide broad spectrum resistance against many strains and isolates
 - Essentially immunity
- Varieties with Ry gene resistance
 - Castle Russet long russet for processing or fresh
 - Payette Russet long russet for processing or fresh
 - Eva round white
 - Ciklamen red variety
- Some varieties with Ny resistance
 - Yukon Gem
 - Premier Russet

Virus Screening Trials – started in 1996

- Plants sprayed with PVY and aphids allowed to transmit
- At harvest, 10 tubers collected
- Greenhouse grow-out in January
 - Visual symptoms are recorded
 - Each plant ELISA tested for PVX, PVY, and PLRV





USDA Aberdeen Breeding Program Potential cultivars with PVY immunity <u>(Ry genes)</u> (slide from 2012)

USDA-ARS Potato Breeding	Marker		Fi	eld testing (2 yrs)	Current Status (seed increase	
Potential cultivar	Ry _{adg}	Ry _{sto}	% PVY	% PLRV	% PVX	and/or yield trials)
A01235-33LB	yes		0	24	10	
A02645-1		yes	0	50	42	
A02645-7	yes	yes	0	75	0	Seed increase
A02645-13		yes	0	72	67	
A02267-5PY	yes	yes	0	67	15	3 rd yr regional
A02675-3		yes	0	62	100	
A02706-4		yes	0	28	58	Seed increase
A03921-2		yes	0	51	14	1 st yr local & national
A03951-5	yes	yes	0	55	0	
A03951-6		yes	0	76	16	
Russet Burbank (susceptible control)			85	85	100	

Varieties with Ry genes (2021)

Type/Variety	use	Gene	Seed acres (2020/2021)	Year released	Developed by or available from:	Ref.			
RUSSETS									
Castle Russet	Process/fresh	Ry _{sto}	60/12	2018	Tri-state, PNW	unpublished			
Payette Russet	Process/fresh	Ry _{sto}	60/81	2015	Tri-state, PNW	Novy et al. 2017			
Fortress Russet	Fresh	Likely Ry _{sto}	0/0 (greenhouse minitubers avail.)	2014	Colorado State Univ.	Dave Holm (pers. Communication)			
Rocky Mountain Russet	Fresh	Likely Ry _{sto}	126/30	2020	Colorado State Univ.	Dave Holm (pers. Communication)			

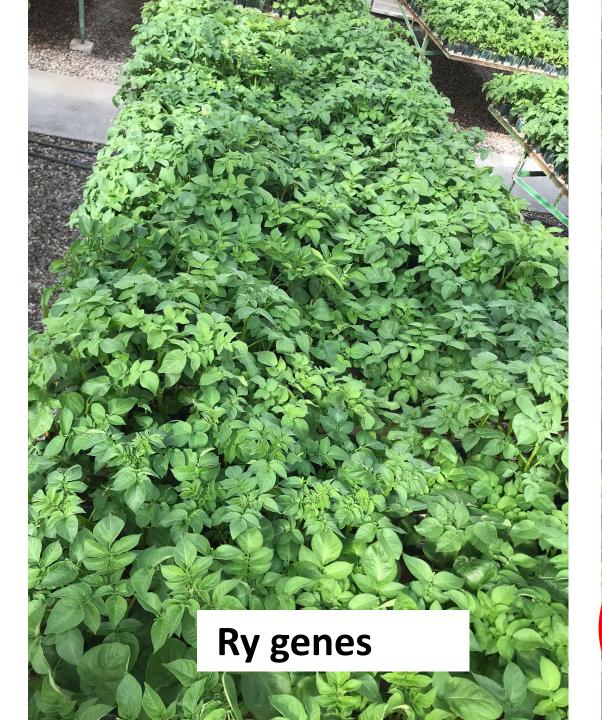
Varieties with Ry genes (2021)

Type/Variety	use	Gene	Seed acres (2020/2021)	Year released	Developed by or available from:	Ref.			
CHIP/FRESH									
Eva	Chip/fresh	Ry_{adg}	74/81 (1537 Canada #7, 2019)	1999	DeJong, Cornell Univ.	Kasai et al. 2000			
Mackinaw	Chip	Ry_{adg}	27/190	2020	Michigan State Univ.	Dave Douches (pers. communication)			
Saginaw Chipper	Chip	Ry_{adg}	0/0 (grown in Australia)	2014	Michigan State Univ.	Dave Douches (pers. communication)			
Lady Liberty	Chip	Ry_{adg}	433/628	2018	Cornell Univ.	W. DeJong (pers. communication)			
AAC Alta Crisp	Chip	Ry_{adg}	Unknown	2017	Agriculture & Agri-Food Canada	B. Bizimungu (pers. Communication)			

Varieties with Ry genes (2021)

Type/Variety	use	Gene	Seed acres (2020/2021)	Year released	Developed by or available from:	Ref.			
RED/SPECIALTY									
Upstate Abundance	high set B size	Ry_{adg}	34/29	2017	Cornell Univ.	W. DeJong (pers. communication)			
Ciklamen	Red	Ry _{sto}	1831/1876	??	Multiple seed companies (origin in Hungary)	Heldak et al. 2007			
Masquerade	Purple-Yellow skin/Yellow flesh	Ry _{sto}	1/3	2013	Colorado State Univ.	Dave Holm (pers. Communication)			
AC99330-1P/Y (Harvest Moon)	Purple/Yellow	Ry _{sto}	3/1.5	2015	Colorado State Univ.	Dave Holm (pers. Communication)			
AAC Confederation	Yellow/Yellow	Ry_{adg}	Unknown	2018	Agriculture & Agri-Food Canada	B. Bizimungu (pers. Communication)			

green house work







Castle Russet / POR06V12-3 📑 (PDF)

A disease resistant russet, suitable for both fresh and processing

Resistant to PVY, TRV, Fusarium dry rot; Insensitive to PMTV



Castle Russet is a suitable for fresh a glycoalkaloid level

Columbia Basin of (PDF)

Payette Russet / A02507-2LB

Resistant to PVY and late blight

Pay of c red low cor Pay has ring Do 138 to /

Summary

- PVY causes yield and quality loss
- Variety x PVY interaction
 - Know the risk factors for varieties
 - Reduce risk by buying seed with low virus readings
- Get a plant health certificate before buying seed
- Resistance to PVY and other diseases is being provided by breeding programs

