

# RUSSET POTATO VARIETIES WITH RESISTANCE TO POTATO MOP-TOP VIRUS AND COORDINATED VARIETY AND VIRUS RESISTANCE RESEARCH EFFORTS.

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# Mop top virus symptoms – Scotland 2007





# Mop top virus symptoms – California, USA 2015



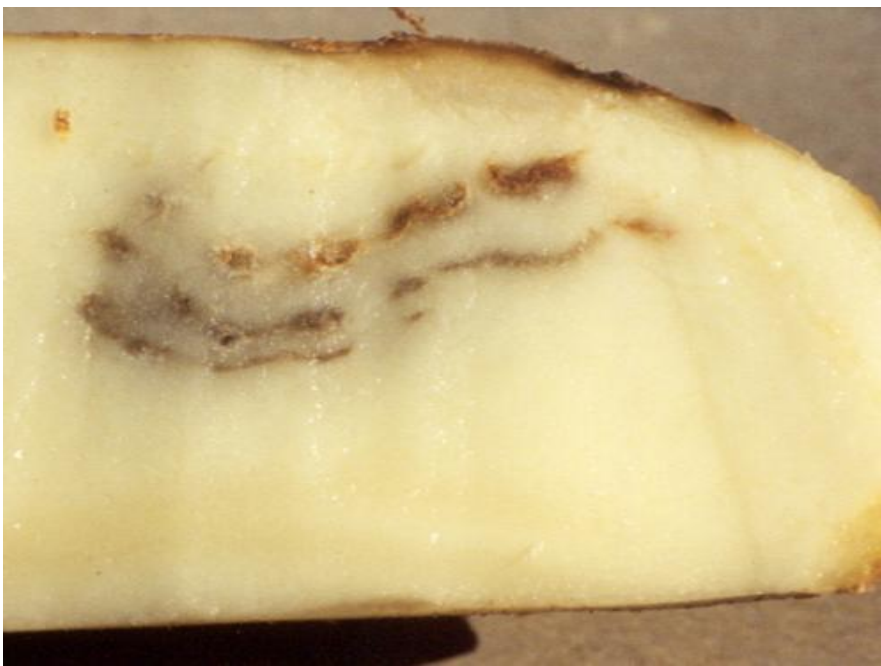




Russet  
Burbank

# PMTV

Modoc



Shepody

A02267-5PY



# Samples taken 2001 and 2002, surveillance study Xu et al. 2004, Plant Dis. 88:363-367

**Table 3.** Incidence of *Potato mop-top virus* (PMTV) detection in the western, central, and eastern zones of the United States and Canada

Zone <sup>a</sup>	Number of states and provinces tested	Number of potato lots	
		Tested	Positive for PMTV
Western	10	1,133	29
Central	8	163	34
Eastern	12	1,859	76
Unknown	Unknown	66	0
Total	30	3,221	139

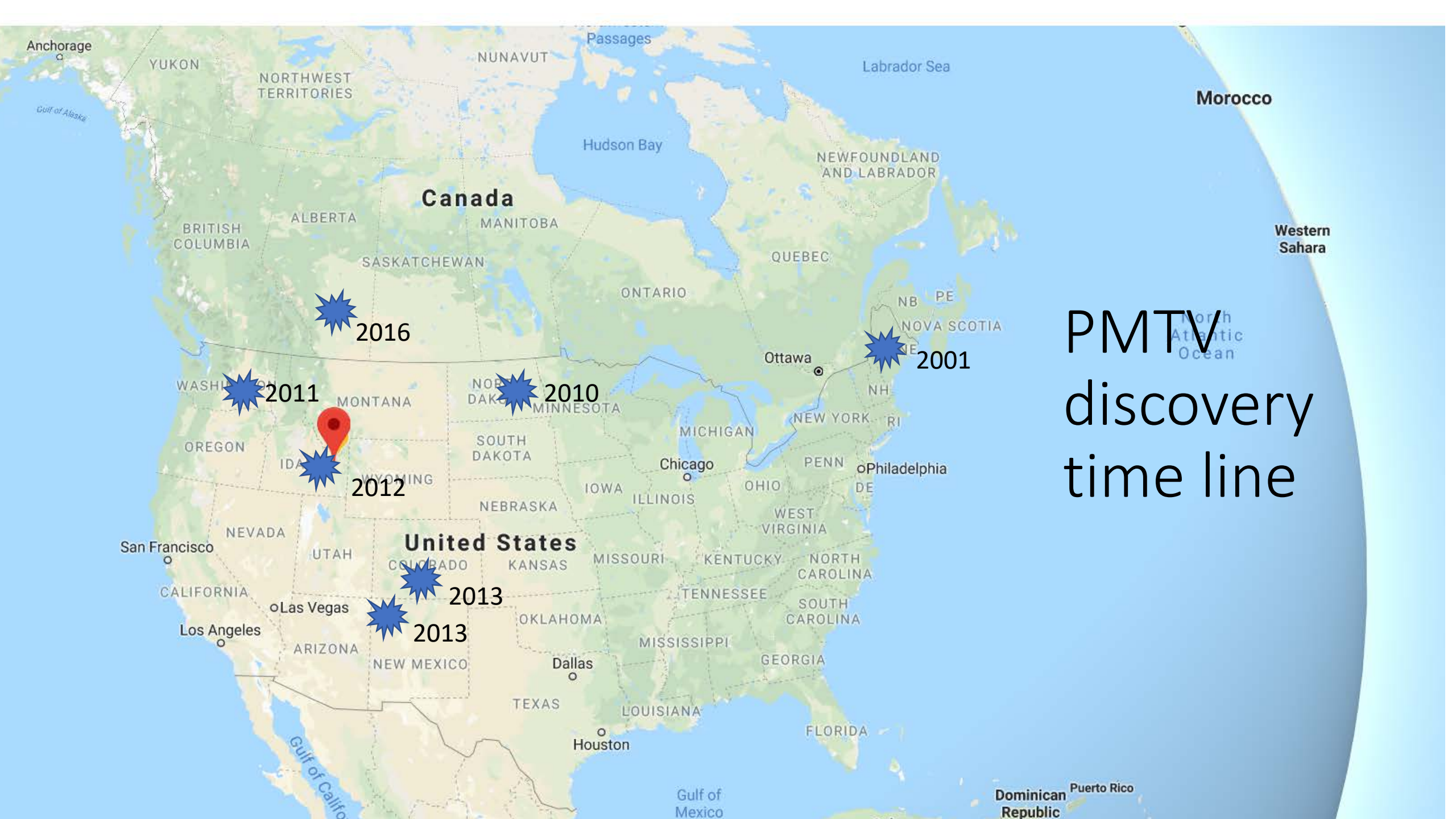
<sup>a</sup> Zones correspond approximately, but not entirely, to Pacific plus Mountain time zone, Central time zone, and Eastern plus Atlantic time zone for the western, central, and eastern zones, respectively.

# U.S./Canada Virus Management Plan

(at shipping point)

<b>Table 1: Eligibility of Seed potatoes related to the Percentage of Internal Tuber Necrosis, apparently caused by PVY complex, PMTV or TRV</b>		
<b>Percentage Internal Tuber Necrosis Scored*</b>	<b>Seed intended for Recertification</b>	<b>Seed intended for Commercial Production</b>
Less than or equal to 0.5%	Eligible	Eligible
Between 0.5 and 2.0%	Eligible if negative lab test for PVY <sup>N/NTN</sup> , PMTV, TRV	Eligible
More than 2.0%	Not eligible	Not eligible
Notes: * Internal tuber necrosis will be calculated as percent incidence {(number of tubers with internal necrosis/number of tubers sampled) x100}.		





PMTV  
discovery  
time line

# Potato Mop Top Virus

- Vector - Powdery scab (*Spongospora subterranea*)
- Infected spore balls of *S. subterranean* survive up to 18 even in the absence of potatoes
- Reduced quality (necrotic arcs and rings)
- Primary infected tubers can be symptomless, but sensitive cultivars can form ringspots or arcs
- Foliar symptoms rare (in USA)
- Emerging disease



# Routine screening for PMTV and TRV resistance, Pacific Northwest

## **Materials and Methods**

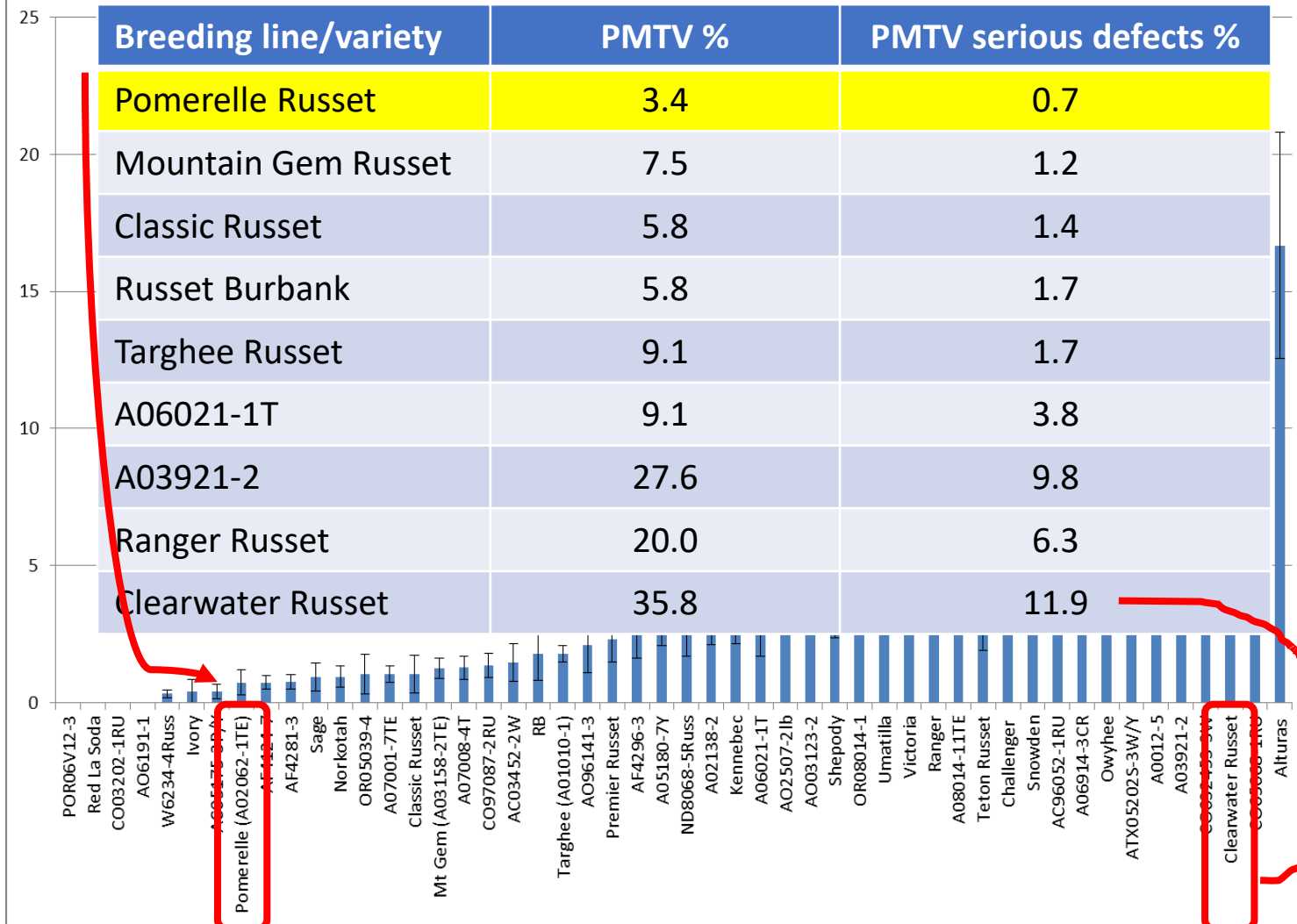
- PMTV
  - Done in infested research field in Prosser, WA area
  - Field fumigated to remove any stubby root nematode vectors
  - Measurements are done by slicing tuber into 4 long sections
  - Counts of necrosis on 8 sides of long sections = severity index
  - Any sign of internal necrosis used to calculate variety percentage
- TRV
  - Done in infested research field in Prosser area
  - Necrosis measurements done as above

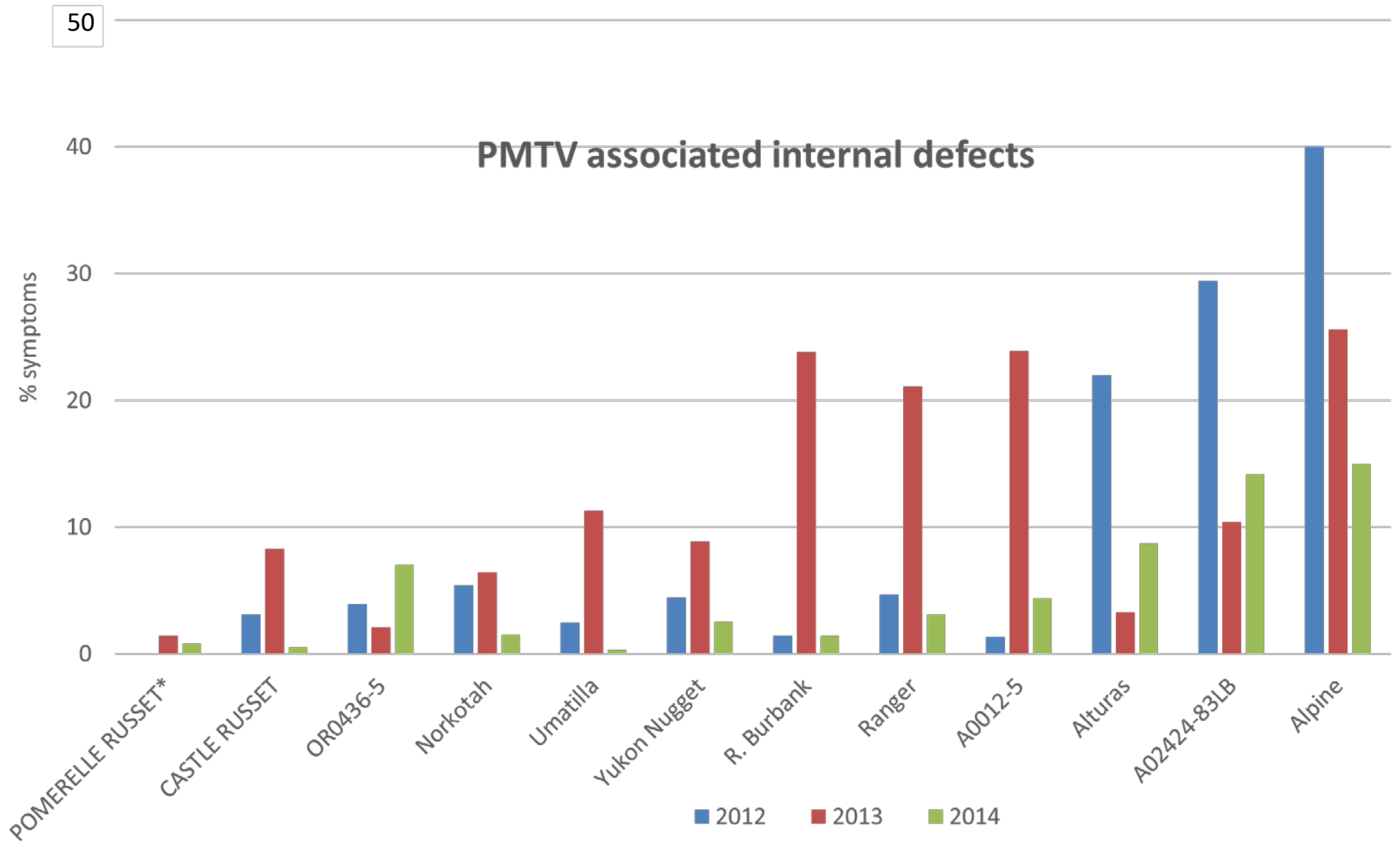
# Materials and Methods (cont.)

- Random tuber samples were tested for PMTV using RT-PCR (n=30) and real-time PCR (n=20).
- Results showed that only PMTV was detected in tubers
- PMTV tuber necrosis increases during storage (4% 1<sup>st</sup> yr, 10% 2<sup>nd</sup> yr)
- PMTV may be latent (low titer) resulting in no symptoms, so classification should be insensitive vs. sensitive
- A lot of russet types are insensitive to PMTV necrosis
  - Russet types are also more resistant to powdery scab



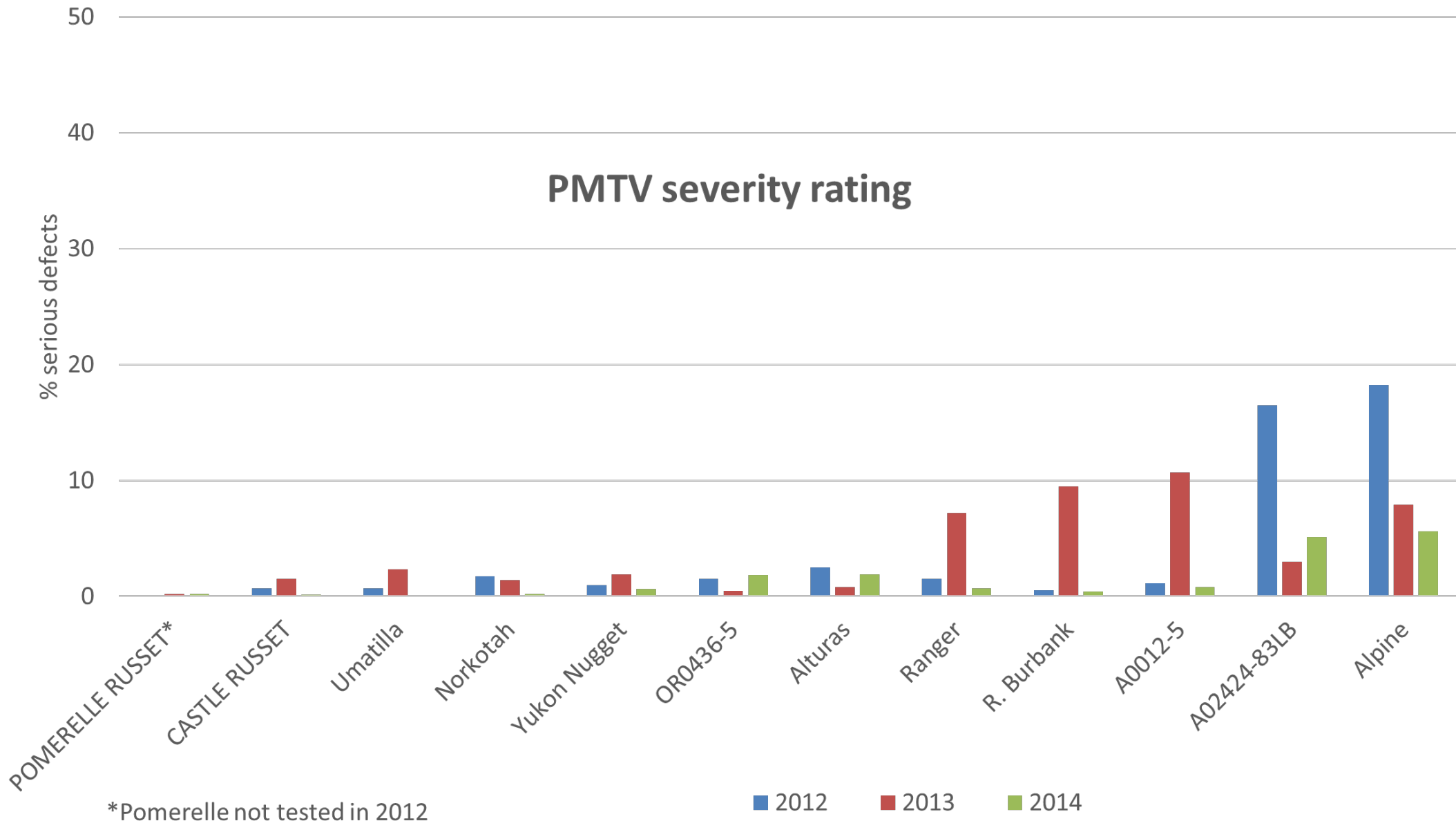
### 2015 Average Disease Severity Index of Potato Mop Top Virus







## PMTV severity rating

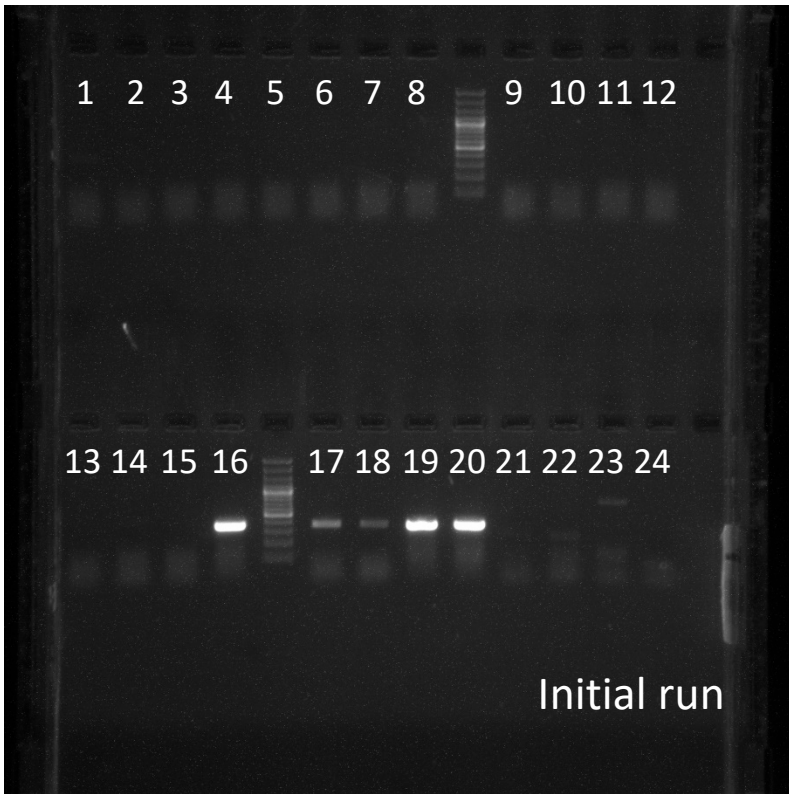


# The insensitive story of PMTV

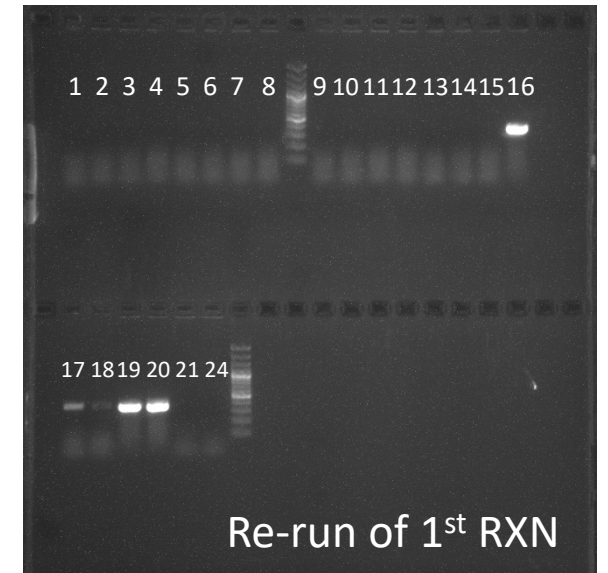
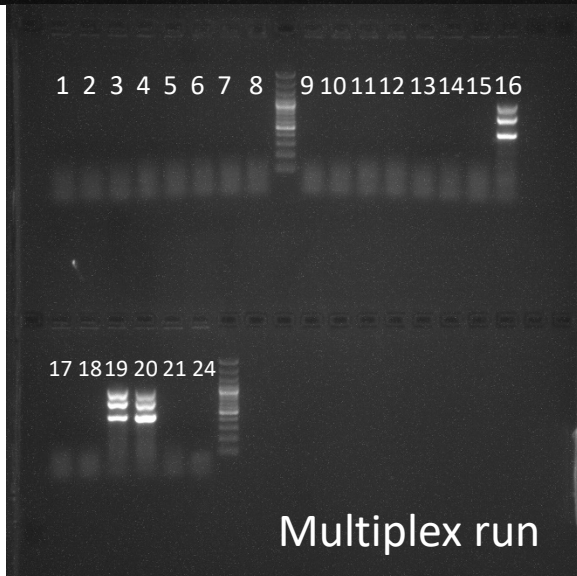
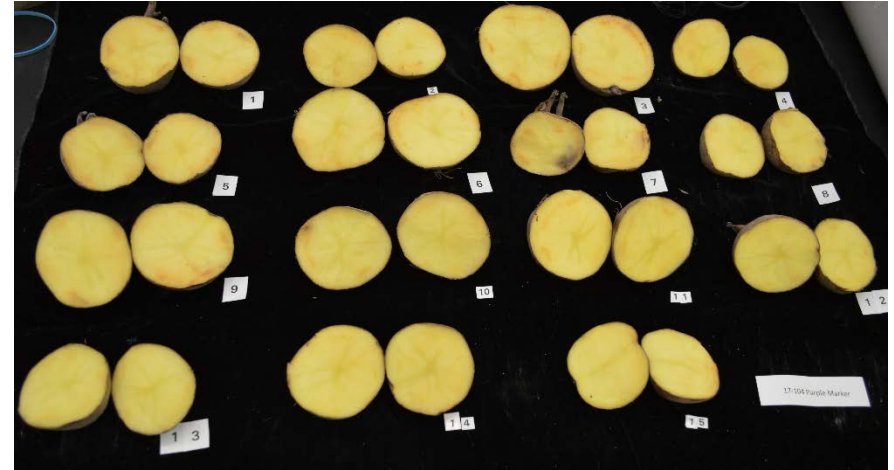
Year	# clones/cvs represented	# Tubers Evaluated	JUST VISUAL		TESTED PCR & VISUAL SYMPTOMS			TESTED PCR & NO SYMPTOMS		
			# Tuber/w int	% w/int	# Tubers Tested w/int	# Pos	% Pos w/int	# Tubers Tested w/o int	# Pos	% Pos w/o int "INSENSITIVE"
2012	63	8686	1155	13.30%	168	115	68.45	410	90	21.95
2014	51	6835	435	6.36%	120	35	40.97	390	77	19.74

From work of Prosser group: Crosslin, Brown, Quick, Hamlin





1. Purple Marker Asymptomatic 1
2. Purple Marker Asymptomatic 2
3. Purple Marker Asymptomatic 3
4. Purple Marker Asymptomatic 4
5. Purple Marker Asymptomatic 5
6. Purple Marker Asymptomatic 6
7. Purple Marker Asymptomatic 7
8. Purple Marker Asymptomatic 8
9. Purple Marker Asymptomatic 9
10. Purple Marker Asymptomatic 10
11. Purple Marker Asymptomatic 11
12. Purple Marker Asymptomatic 12
13. Purple Marker Asymptomatic 13
14. Purple Marker Asymptomatic 14
15. Purple Marker Asymptomatic 15
16. Purple Marker Symptomatic
17. Purple Marker Asymptomatic Bulk #1-7
18. Purple Marker Asymptomatic Bulk #8-15
19. + Control (tuber)
20. + Control (tuber)
21. - Control (tuber)
22. - Control (tuber)
23. - Control (tuber)
24. H<sub>2</sub>O



Kylie Swisher USDA-ARS

# Varieties at Washington Screening Trials

Variety	Year	Incidence	Severity	Use
Pomerelle Russet	2014	0.8	0.2	Early maturity, process/fresh
	2015	3.4	0.7	
La Belle Russet	2014	0.0	0.0	Early maturity, process/fresh
	2015	9.1	3.8	
Castle Russet	2014	0.5	0.1	Medium maturity, process/fresh
	2015	0.0	0.0	
(@ North Dakota)	2015	0.0	0.0	
Clearwater Russet	2014	22.5	10.2	Medium/late maturity, Process/fresh
	2015	35.8	11.9	

# Different trial - Seed Lot testing- PMTV and TRV

-essentially a survey for virus amounts in the industry

## Washington state

- Chuck Brown/Mark Pavek
  - 2016: 0.29% TRV-positive tubers  
1.76% PMTV-positive tubers
  - 2017: 0% TRV-positive tubers  
4.07% PMTV-positive tubers
  - Varieties included: Umatilla, Ranger, Shepody, Nordonna, Norkotah, Agata, and Jelly
  - All + tubers were symptomless carriers in yr. 1, and all but one tuber were symptomless carriers in yr. 2

## Oregon state

- Frost
  - 88 seed lots assayed for TRV and PMTV
  - No TRV or PMTV was detected in OR seed lot trials



# PCR test for detection of PMTV from soil sample

(last week! First Look Phytopathology)

**Development and application of a reverse transcription real-time PCR (RT-qPCR) and droplet digital PCR (RT-ddPCR) assays for the direct detection of Potato mop top virus in soil.** B. Pandey, I. Mallik, N.C. Gudmestad, Phytopathology 2019

- RT-qPCR and droplet digital (RT-ddPCR) assays of the total RNA extracted directly from soil to detect PMTV
- Both assays detected PMTV from all soil types used in samples with less than 10 PMTV copies per  $\mu\text{l}$
- First report of real-time PCR and droplet digital PCR for detection of PMTV directly from soil.

**Table 1.** Primers and probes for PMTV detection and their preliminary test results.

Primer/probe (Reference)	Sequence (5'-3') (Fluorophore)	Amplicon size (nt) <sup>a</sup>	RNA extracted from <i>Sss sporosori</i> <sup>b</sup> Ct <sup>c</sup> value ± SD <sup>d</sup> (Detection frequency)	RNA extracted from manually spiked soil <sup>e</sup> Ct value ± SD (Detection frequency)	RNA extracted from naturally infested soil samples <sup>f</sup> Ct values (Detection frequency)
PMTV 601 F PMTV 601 R PMTV 603 P (This study)	ACCGAACGCTTTGGTGGAAAGT CGGAAGCTTCTCTCGGACCT CGTCTTGCCCGCCCTTCGCCGT (FAM) <sup>g</sup>	157	25.87 ± 0.59 (100%)	34.19 ± 0.89 (30%)	>35 (25%)
PMTV 501 F PMTV 501 R PMTV 503 P (This study)	TGACGCTTGGGACCATGAGC GACACCTGGCTCAACACGCT ACTTCCTCACGGCAGCCTTCATGGCC T (FAM)	144	24.80 ± 0.56 (100%)	34.36 ± 1.16 (20%)	>40 (0%)
PMTV 401 F PMTV 402 R PMTV 403 P (This study)	GGAAGTTCACCTTGTTGGTGATAAA GAAGCTTCTCTCGGACCTAATC TGTAGCGTTGCAGACAGTGAACGG (FAM)	140	22.58 ± 0.38 (100%)	27.47 ± 0.91 (100%)	~25 to ~31 (90%)
PMTV-1948F PMTV-2017R PMTV-1970 (Mumford et al. 2000)	GTGATCAGATCCGCGTCCTT CCACTGCAAAAAGAACCGATTTC ACC AGA ACT ACG GTG CCG CGT CG (FAM)	70	25.48 ± 0.19 (100%)	35.23 ± 0.68 (40%)	> 35 (10%)

<sup>a</sup> nt – nucleotide<sup>b</sup> RNA with approximately 1×10<sup>3</sup> µl<sup>-1</sup> copies of viral target.<sup>c</sup> Ct – Mean cycle threshold and only positive reactions were used in the calculation of the mean Ct value

# Story of how to use new tools

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- Soil type – loamy fine sand
- By 1906 sub-irrigation was used in the area
- By 1970s sprinkler irrigation was replacing sub-irrigation
- One of the areas implicated in Xu et al. 2004 surveillance paper

USDA ARS Idaho Soil - *S. subterranea* detection and quantification, 10-13-17, NDSU lab  
Mallik and Pandey.

Submitted by: Jonathan  
Whitworth

Sample	Fluor	Target	Cq	SQ	Sporosori/g soil	PS	<b>PMTV</b>
IDS-2	FAM	Sporosori	24.12	1057.02	4.2E+03	M	Positive
IDS-7	FAM	Sporosori	24.45	1064.84	4.3E+03	M	Positive
Positive Control	FAM	Sporosori	18.42	354853.1	1.4E+06	H	
Negative Control	FAM	Sporosori	-	-	-	N	
Water Blank	FAM	Sporosori	-	-	-	N	

- *S. Subterranea* detection by van de Graaf et al. 2003 primers
- PMTV detected in soil samples using real-time RT-PCR, NDSU lab protocol





Pomerelle Russet: Early maturity, process/fresh



Castle Russet: Medium maturity, process/fresh



## Solutions to grower problems with PMTV

- Ability to survey fields for presence of PMTV
- Varieties that have little to no symptoms in infested fields.
  
- **CURRENT STUDY**
- Pomerelle and Castle Russet – resistant
- Russet Burbank and Clearwater Russet – susceptible
- Planted in infested field
- At harvest:
  - tuber symptoms will be rated
  - Samples for PCR confirmation of PMTV will be taken from symptomatic and asymptomatic tubers









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