

Supplementary

Table S1. Potato cultivars and breeding lines used to assess tolerance to PSTVd

№	Cultivar	Year of inclusion in the Russian State Register	Origin	Reproduction
1	Avrora	2006	Russia	Mini-tubers
2	Arizona	2013	Netherlands	Super elite
3	Ariel	2021	Russia	Super-super elite
4	Armada	Not registred	Russia	Breeding line
5	Bellarosa	2006	Germany	Super elite
6	Berkut	Not registred	Kazakhstan	Breeding line
7	Bernina	2017	Germany	Super elite
8	Bizon	Not registred	Russia	Breeding line
9	Briz	2009	Belarus	Elite
10	Charoit	2014	Russia	Super-super elite
11	Colomba	2013	Netherlands	Super elite
12	Donata	2019	Germany	Super elite
13	Elizaveta	1996	Russia	Mini-tubers
14	Favorit	2014	Russia	Super-super elite
15	Flagman	Not registred	Russia	Breeding line
16	Gala	2008	Russia/Germany	Mini-tubers
17	Impala	1995	Netherlands/Russia	Super elite
18	Krepysh	2005	Russia	Super-super elite
19	Labadia	2010	Netherlands/Russia	Elite
20	Madeira	2017	Germany	Super elite
21	Manifest	2014	Belarus	Elite
22	Meteor	2013	Russia	Super elite
23	Mirazh	Not registred	Russia	Breeding line
24	Nandina	2015	Germany	Super elite
25	Navigator	Not registred	Russia	Breeding line
26	Nevskiy	1982	Russia	Elite
27	Phioletovyi	2014	Russia	Super elite
28	Queen Anna	2015	Germany	Super elite
29	Riviera	2013	Netherlands/Russia	Mini-tubers
30	Sanibel	2019	Germany	Super elite
31	Sapsan	Not registred	Russia	Breeding line
32	Sineglazka2016	2019	Russia	Elite
33	Siurpriz	2021	Russia	Super-super elite
34	Sorentina	2020	Germany	Super elite
35	Sprinter	Not registred	Russia	Breeding line
36	Udacha	1994	Russia	Mini-tubers
37	Vineta	2001	Russia/Germany	Super elite
38	1923-3	Breeding line	Russia	Breeding line
39	4434-1	Breeding line	Russia	Breeding line



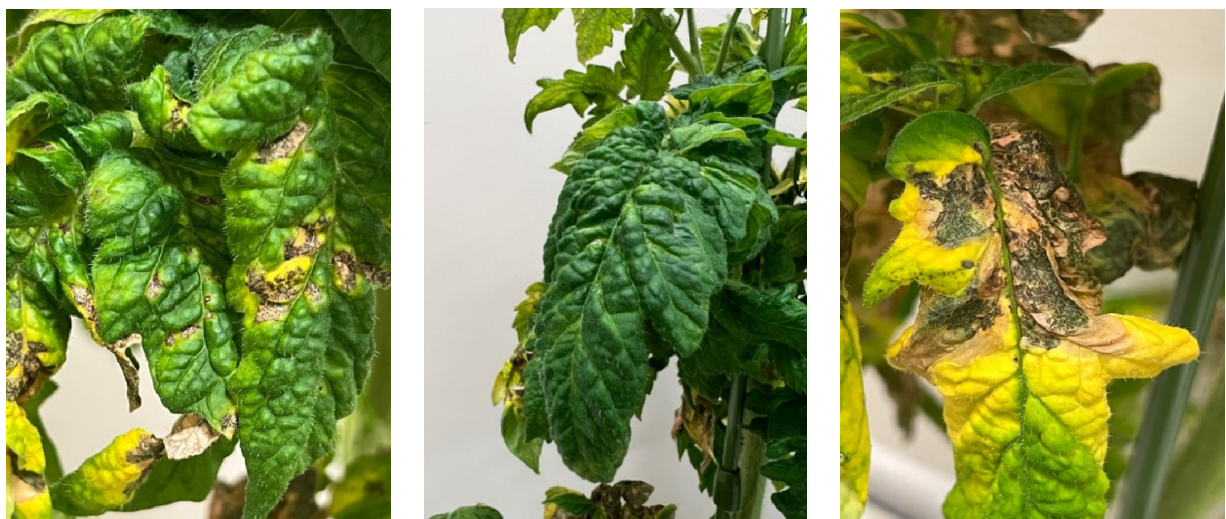
VP87



FP10-13



VP35



NicTr-3

Figure S1. Symptoms on the leaves of tomato cv. Rutgers at 60 dpi with four PSTVd strains.

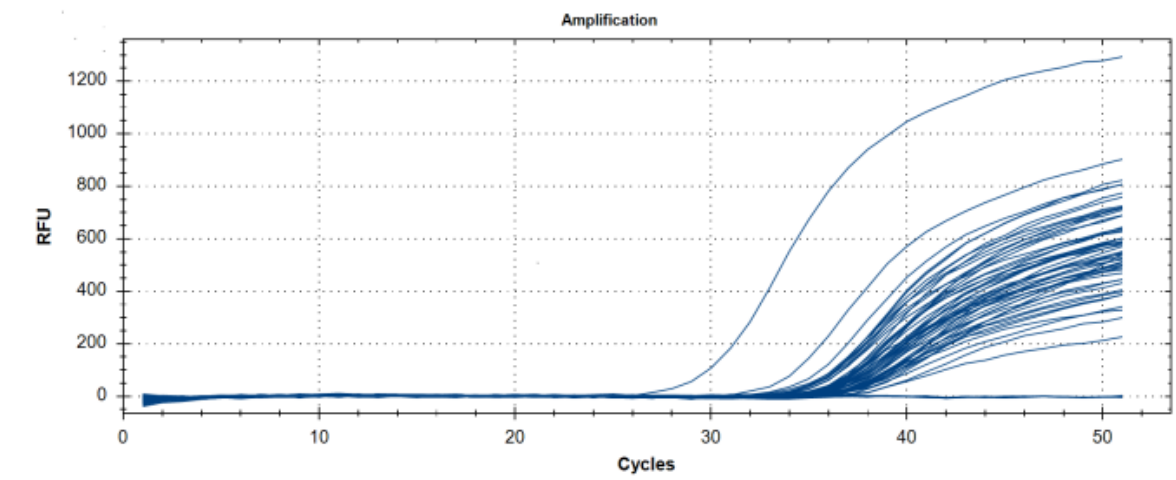


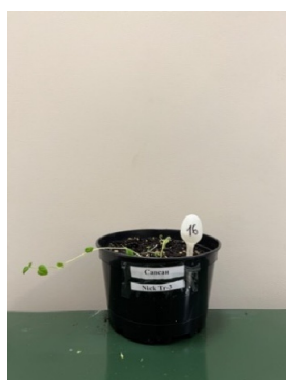
Figure S2. The FAM channel of real time PCR for detection of potato spindle tuber viroid in different potato cultivars.

Table S2. Symptoms on second generation plants derived from PSTVd-infected but normal in shape tubers

Cultivar	Strain	Delayed sprouting, days in compare with mock	Symptoms on the haulm	Number/average tubers weight per plant	
				PSTVd-infected	Mock
Arizona	VP87	5	TS, SL	no	5/110.4
Bernina	NicTr3	13	TS, SL, NEC	2/1.70	4/98.7
Bernina	FP10-13	>30	TS, SL, NEC	no	4/98.7
Donata	NicTr3	No sprouts	–	–	3/100.3
Elizaveta	VP35	7	TS, SL, NEC	1/0.75	3/85.2
Colomba	NicTr3	6	TS, SL, NEC	2/1.75 D	4/164.7
Krepysh	VP87	19	TS, SL	no	3/81.4
Labadia	FP10-13	10	TS, SL	2/0.10 D	4/83.1
Labadia	VP35	10	TS, SL, NEC	1/1.20	4/83.1

Mirazh	NicTr3	6	TS, SL	6/1.38	7/112.8
Navigator	NicTr3	6	TS, SL, NEC	3/8.50	4/117.8
Nevskiy	NicTr3	10	TS, SL, NEC	1/0.11 D	5/97.4
Nevskiy	VP87	5	TS, SL, NEC	3/17.87	5/97.4
Riviera	NicTr3	No sprouts	–	–	4/102.5
Sapsan	NicTr3	12	TS, SL	no	3/84.8
Sorentina	NicTr3	10	TS, SL	no	4/96.2
Sorentina	VP87	12	TS, SL	no	4/96.2
Sorentina	FP10-13	>30	TS, SL, NEC	no	4/96.2
Udacha	NicTr3	12	TS, SL, NEC.	9/2.29 M	4/103.7
Udacha	VP35	5	TS, SL, NEC.	1/0.11 M	4/103.7
Favorit	NicTr3	>30	TS, SL	no	5/125.8
Flagman	VP35	5	TS, SL, NEC	3/0.33 M	4/112.6

Note: TS – thin stem, SL – small leaves, NEC – leaf necrosis, D – deformation, M – tubers miniaturization; no – no tubers.



1



2



3

Figure S3. Potato cultivars 90 days after planting with PSTVd-infected tubers that appeared 30-48 days later 1 – Sapsan, strain NicTr-3; 2 – Favorit, strain NicTr-3; 3 – Bernina, strain FP10-13.








Table S3. Average tuber weight per plant of PSTVd-infected (strain NicTr-3), viral-infected, and mixed viroid (strain NicTr-3)/viral infected plants












Netherlands viral infected plants			
Virus/viroid	Number of plants	Average tuber weight per plant, g	
		Infected	Mock, mean value for 6 plants of each cultivar
cv. Impala			
PVX+PSTVd	1	32.7	129.7











PVM+PSTVd	1	29.8	
PVY+PSTVd	1	20.4	
PVX+PVS+PVM+PSTVd	4	43.3	
PVX+PVS+PVM	3	109.8	
PVX+PVS	1	109.6	
PVX+PVY+PVS+PVM	1	67.8	
PSTVd	2	32.4	
cv. Colomba			
PVY+PSTVd	3	89.8	170.4
PVY	3	160.8	
PVX+PVY+PSTVd	1	124.1	
PVM+PSTVd	1	84.6	
PVM+PVY+PSTVd	1	134.1	
PVY+PVS+PVM+PSTVd	1	144.3	
PSTVd	6	117.7	
cv. Sanibel			
PVM+PSTVd	1	75.3	108.7
PVX+PVM+PSTVd	1	46.2	
PVY	1	45.0	
PVM	1	68.0	
PSTVd	8	69.9	
cv. Favorit			
PVX+PSTVd	1	67.1	125.8
PVX+PVM+PSTVd	1	36.1	
PSTVd	3	65.6	
cv. Navigator			
PVM+PSTVd	3	54.1	117.8








PVY+PVS+PVM+PSTVd	1	92.6	
PSTVd	2	62.8	
cv. Phioletovii			
PVY+PSTVd	2	15.6	120.9
PVY+PVS+PSTVd	2	24.1	
PSTVd	2	23.7	
cv. Briz			
PVM+PSTVd	1	9.3	110.3
PSTVd	4	28.3	
cv. Vineta			
PVY+PVS+PSTVd	2	37.6	98.4
PVS+PSTVd	1	22.9	
PSTVd	1	27.9	
cv. Bizon			
PVM+PSTVd	1	No tuber	95.9
PSTVd	2	No tuber	
cv. Labadia			
PVY+PSTVd	1	21.6	83.1
PVY+PVS+PSTVd	1	43.4	
PSTVd	2	60.1	
cv. Sineglazka 2016			
PVY+PSTVd	1	No tuber	96.2
PSTVd	3	23.3	






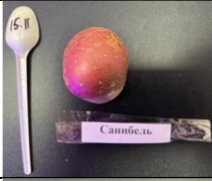


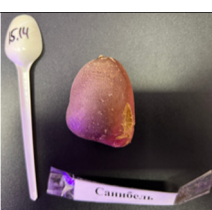
Table S4. Symptoms on tubers of three potato cultivars when infected with PSTV strain NicTr-3 and mixed viral/viroid infection








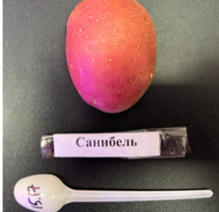
	Number of tubers	Weight, g	Symptoms
cv. Colomba			
PSTVd+PVY	8	93.7	
PSTVd+PVY	3	106.8	
PSTVd+PVY	3	68.8	
Mean value for PSTVd+PVY	4.66	89.77	
PVY	5	156.3	
PVY	5	141.5	
PVY	4	184.5	
Mean value for PVY	4.66	160.77	
PSTVd	6	33.9	

PSTVd	5	88.8	
PSTVd	10	145.1	
PSTVd	7	134.3	
PSTVd	3	135.3	
PSTVd	9	168.9	
Mean value for PSTVd	6.67	117.72	
Mock 1	7	173.2	
Mock 2	5	167.7	
Mock 3	10	166.3	
Mock 4	9	174.2	
Mean value for Mock	7.75	170.35	
PVM	5	84.6	
PSTVd+PVX+PVY	8	124.1	

PSTVd+PVY+PVS+PVM	6	144.3	
PVY+PVM	8	134.1	
cv. Impala			
PSTVd	7	28.9	
PSTVd	2	32.4	
Mean value for PSTVd	4.5	30.65	
PSTVd+PVY	2	20.4	
PSTVd+PVM	2	29.8	
PSTVd+PVX	4	32.7	
PSTVd+PVX+PVS	6	109.6	
PSTVd+PVY+PVM	3	54.6	
PSTVd+PVX+PVS+PVM	2	35.0	

PSTVd+PVX+PVS+PVM	2	9.2			
PSTVd+PVX+PVS+PVM	6	85.9			
Mean value for PSTVd+PVX+PVS+PVM	3.3	43.37			
PSTVd+PVY+PVX+PVS+PVM	2	67.8			
PVX+PVS+PVM	6	98.3			
PVX+PVS+PVM	8	109.6			
PVX+PVS+PVM	3	121.5			
Mean value for PVX+PVS+PVM	5.67	109.8			
Mock 1	6	187.5			

Mock 2	7	71.8	
Mean value for Mock	6.5	129.65	
cv. Sanibel			
PSTVd	3	56.8	
PSTVd	2	78.0	
PSTVd	2	99.1	
PSTVd	3	79.2	
PSTVd	1	45.7	
PSTVd	3	57.3	
PSTVd	2	44.9	
Mean value for PSTVd	2.28	65.86	
PSTVd +PVY	1	45.0	

PSTVd +PVM	2	75.3		
PSTVd +PVM	2	68.0		
Mean value for PSTVd+PVM	2	71.65		
PSTVd +PVM+PVX	2	46.2		
Mock 1	4	127.2		
Mock 2	3	129.5		
Mock 3	2	104.6		
Mock 4	2	90.4		
Mock 5	1	92.0		
Mean value for Mock	2.4	108.74		

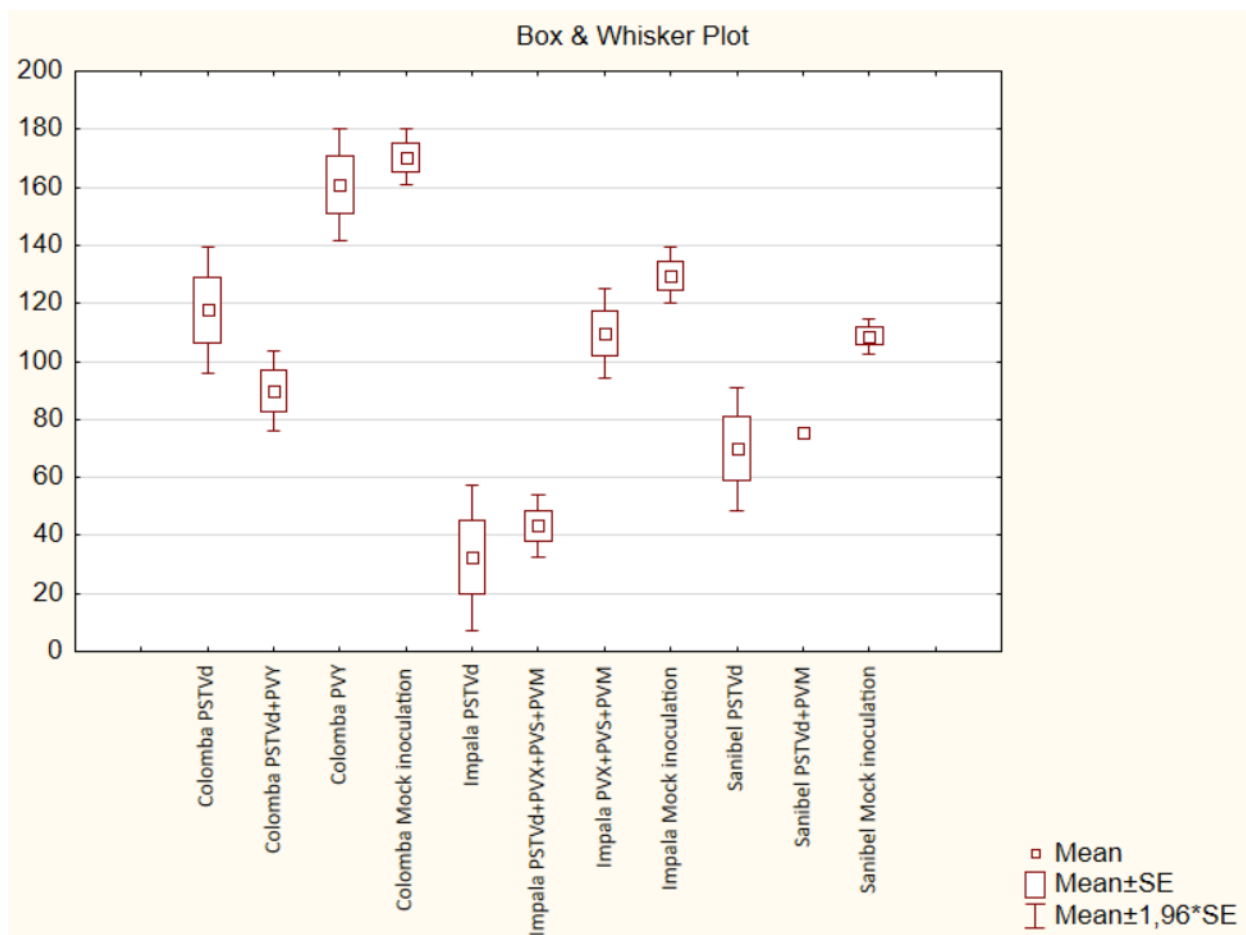


Figure S4. Mean error when comparing weight of tubers per plant infected with PSTVd (strain NickTr-3), viral-infected and viroid/viral- mixed infected of three potato cultivars.

Table S5. Student's *t*-test with Bonferroni correction when comparing mean weight of tubers per plant infected with PSTVd (strain NickTr-3), viral-infected and viroid/viral- mixed infected of three potato cultivars. All significance levels less than 0.05 are highlighted in red.

A1-A4 – cv. Colomba: A1 – PSTVd, A2 – PSTVd+PVY, A3 – PVY, A4 – Mock; A5-A8 – cv. Impala: A5 – PSTVd, A6 – PSTVd+PVX+PVS+PVM, A7 – PVX+PVS+PVM, A8 – Mock; A9-A11 – cv. Sanibel: A9 – PSTVd, A10 – PSTVd+PVM, A11 – Mock.

Cell №	Bonferroni test; variable Mass of potato tubers (Spreadsheet3)											
	Probabilites for Post Hoc Tests											
	Error: Between MS = 377.87, <i>df</i> = 37.000											
	Level A	(1) 117.7	(2) 89.8	(3) 160.8	(4) 170.4	(5) 32.4	(6) 43.3	(7) 109.8	(8) 129.7	(9) 69.9	(10) 75.3	(11) 108.7
1	A1		1.00	0.18	0.00	0.00	0.00	1.00	1.00	0.00	1.00	1.00
2	A2	1.00		0.00	0.00	0.14	0.19	1.00	0.34	1.00	1.00	1.00
3	A3	0.18	0.00		1.00	0.00	0.00	0.15	1.00	0.00	0.03	0.03
4	A4	0.00	0.00	1.00		0.00	0.00	0.00	0.05	0.00	0.00	0.00
5	A5	0.00	0.14	0.00	0.00		1.00	0.00	0.00	1.00	1.00	0.00
6	A6	0.00	0.19	0.00	0.00	1.00		0.00	0.00	1.00	1.00	0.00
7	A7	1.00	1.00	0.15	0.00	0.01	0.00		1.00	0.24	1.00	1.00
8	A8	1.00	0.34	1.00	0.05	0.00	0.00	1.00		0.00	0.75	1.00
9	A9	0.00	1.00	0.00	0.00	1.00	1.00	0.24	0.00		1.00	0.04
10	A10	1.00	1.00	0.03	0.00	1.00	1.00	1.00	0.75	1.00		1.00
11	A11	1.00	1.00	0.03	0.00	0.00	0.00	1.00	1.00	0.04	1.00	

Table S6. Student's *t*-test with Bonferroni correction when comparing weight of tubers per plant of PSTVd-infected, viral-infected and viroid/viral-mixed infected plants regardless of cultivar: A1 - Mock ; A2 - PVY; A3 - PSTVd; A4 - PVY + PSTVd ; A5 - PVM + PSTVd ; A6 - PVY + PVS + PSTVd . All significance levels less than 0.05 are highlighted in red.

Bonferroni test; variable Масса клубней (Spreadsheet3)							
Probabilities for Post Hoc Tests							
Error: Between MS = 911,45, df = 116,00							
Cell No.	Уровень A	{1} 115,31	{2} 131,85	{3} 61,552	{4} 48,943	{5} 51,614	{6} 33,360
1	A1		1,000000	0,000000	0,000003	0,000008	0,000001
2	A2	1,000000		0,000365	0,000390	0,000676	0,000055
3	A3	0,000000	0,000365		1,000000	1,000000	0,811436
4	A4	0,000003	0,000390	1,000000		1,000000	1,000000
5	A5	0,000008	0,000676	1,000000	1,000000		1,000000
6	A6	0,000001	0,000055	0,811436	1,000000	1,000000	