

Resistance to potato virus Y in potato: broad spectrum versus strain-specific resistance

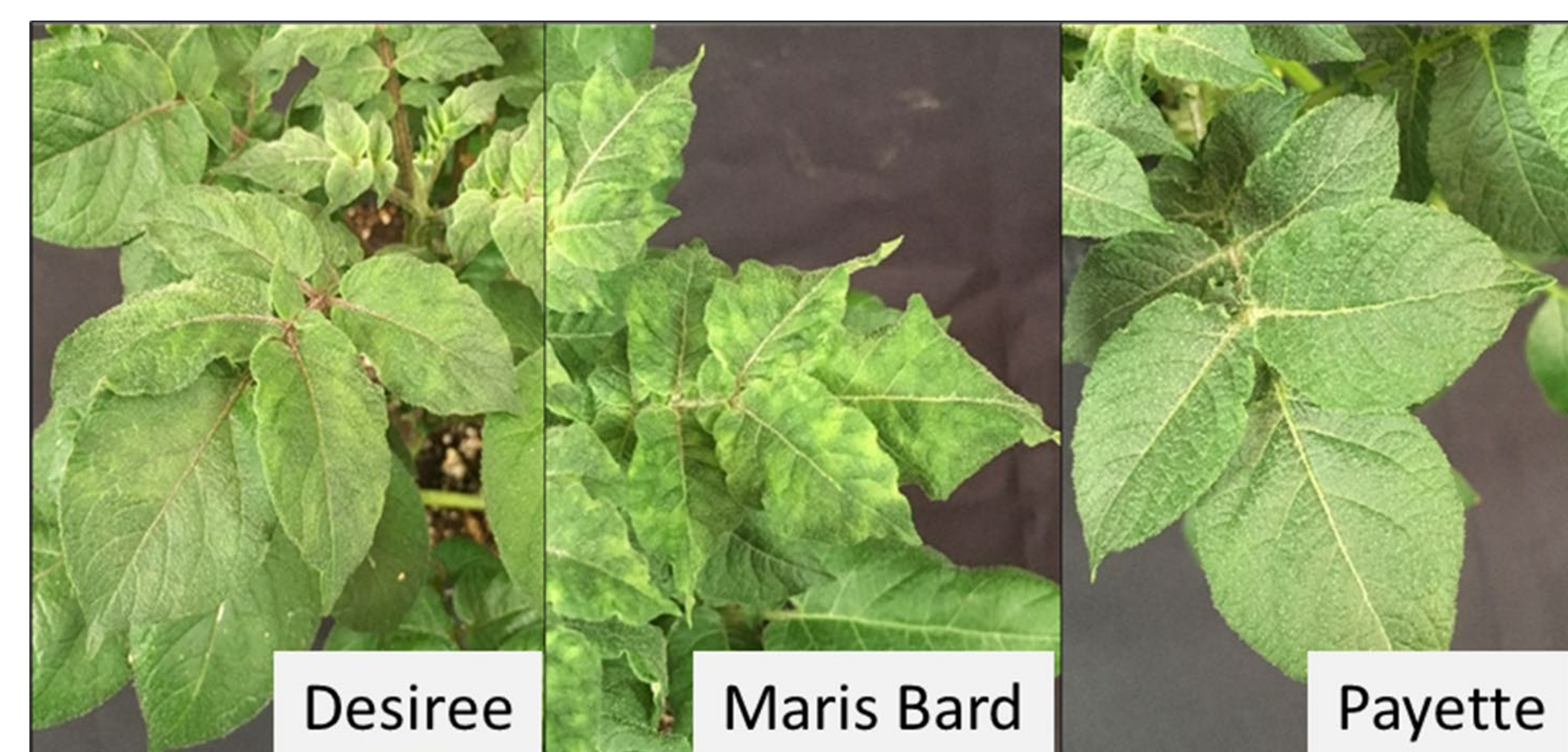
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Description of research: Three potato cultivars, Payette Russet, Dark Red Norland, and Chieftain were challenged with four strains of potato virus Y (PVY), PVY^O, PVY^{Eu-N}, PVY^{N-Wi}, and PVY^{NTN}. Cultivars Dark Red Norland and Chieftain exhibited strain-specific, hypersensitive resistance to PVY^O and PVY^{NTN} strains. Payette Russet was found immune to the four strains of PVY and was additionally challenged with the total of 18 isolates of PVY representing 13 genetic variants of the virus. None of the 18 isolates of the virus was found able to infect Payette Russet, confirming the broad specificity of the *Ry_{sto}* gene present in the Payette Russet genome.

Isolates	Strain	Genotype	Tobacco bioassay	Serotype	Genome sequence	Reference
Tb60	PVY ^O	PVY ^O	Mos	O	NA	Lorenzen et al. 2006a
Oz	PVY ^O	PVY ^O	Mos	O	EF026074	Baldauf et al. 2006
ID269	PVY ^O	PVY ^O -O5	Mos	O5	FJ643477	Karasev et al. 2010
N1	PVY ^{N-Wi}	PVY ^{N-Wi}	VN	O	HQ912863	Karasev et al. 2011
Alt	PVY ^{N-O}	PVY ^{N-O}	VN	O	AY884985	Lorenzen et al. 2006a
Pondo4	261-4	261-4	VN	O	KY848023	Green et al. 2017a
Mont	PVY ^N	PVY ^N	VN	N	AY884983	Lorenzen et al. 2006a
HR1	PVY ^Z	PVY ^{NTN} (syn. PVY ^Z -NTN)	VN	N	FJ204166	Hu et al. 2009
L26	PVY ^Z	PVY ^{NTN} (syn. PVY ^Z -NTN)	Mos	N	FJ204165	Hu et al. 2009
NE-11	NE-11	NE-11 (long)	VN	N	DQ157180	Piche et al. 2008; Green et al. 2017a
ID20	NE-11	NE-11 (short)	VN	N	HQ912867	Karasev et al. 2011; Green et al. 2017a
PVY-AGA	E	E	VN	N/AST	JF928459	Galvino-Costa et al. 2012
HI-14	C	C1	Mos	O	KX580384	Chikh-Ali et al. 2016
Poha2	C	C-Poha	Mos	O	MF134862	Green et al. 2017b
Poha6	C	C-Poha	Mos	-	MF134866	Green et al. 2017b
Tam13	SA-N	Tamarillo	VN	N	MT380736	Green et al. 2020a
Tam15	SA-N	Tamarillo	VN	-	MT380738	Green et al. 2020a
Tam17	SA-N	Tamarillo	NS	N	MT380740	Green et al. 2020a

Table 1. PVY isolate collection at the Virology lab, University of Idaho.



Isolate (PVY strain)	Payette Russet		Desiree		Maris Bard	
	Local	Systemic	Local	Systemic	Local	Systemic
Tb60 (PVY ^O)	NI	NI	VN, LL	M, LL, SN, Cr, LD	VN, LL	M, Cr, LD
Oz (PVY ^O)	NI	NI	VN, LL	M, LL, SN, Cr, LD	VN, LL	M, Cr, LD
ID269 (PVY ^{O5})	NI	NI	VN, LL	M, SN, LL, LD, WSR	VN, LL	M, SN, LD
N1 (PVY ^{N-Wi})	NI	NI	NS	M, Cr	NS	M, Cr, St
Pondo4 (PVY-261-4)	NI	NI	NS	M, Cr	NS	M, Cr, St
Alt (PVY ^{N-O})	NI	NI	NS	M	NS	M
L26 (PVY ^{NTN})	NI	NI	NS	M, St	VN, LL	M, SN, LL, LD
HR1 (PVY ^{NTN})	NI	NI	NS	M, St	VN, LL	M, SN, LL, LD
ID20 (PVY-NE11, short)	NI	NI	VN	M, SN, LL	VN, LL	M, Cr, SN, LL, LD
NE-11 (PVY-NE11, long)	NI	NI	NS	M, SN, LL	VN, LL	M, Cr, SN, LL, LD
AGA (PVY ^E)	NI	NI	NS	M	NS	M
Mont (PVY ^{Eu-N})	NI	NI	NS	NS	NS	NS
H-14 (PVY ^{C1})	NI	NI	NI	NI	LL	NI
Poha2 (PVY ^C , Poha)	NI	NI	NS	NI	LL	NI
Poha6 (PVY ^C , Poha)	NI	NI	NS	NI	NS	NI
Tam13 (PVY ^{SA-N})	NI	NI	NI	NI	NI	NI
Tam15 (PVY ^{SA-N})	NI	NI	NI	NI	NI	NI
Tam17 (PVY ^{SA-N})	NI	NI	NI	NI	NI	NI

Table 2. Symptoms expressed by Payette Russet and control cultivars Desiree and Maris Bard when tested against different strains of PVY mechanically inoculated using the inoculum from PVY isolate collection (see Table 1). M, Mosaic; Cr, crinkling; St, stunting; LL, local lesions; SN, systemic necrosis; LD, leaf drop; MM, mild mosaic. "NS" designates no symptoms, virus infection was confirmed by ELISA and RT-PCR.

Fig. 1. Symptoms in upper, non-inoculated leaves of three cultivars inoculated with PVY isolate N1 (PVY^{N-Wi}), 29 days post-inoculation: cv. Desiree and cv. Maris Bard showing mosaic and mottling; and asymptomatic leaves of cv. Payette Russet.

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RESULTS AND DISCUSSION:

Introgression of the strain-specific *Ny* genes conferring resistance to only specific strains of PVY in newly released potato cultivars, such as PVY^O and PVY^C, does not actually solve the PVY problem and only shifts the strain composition in the field towards other, recombinant strains, such as PVY^{N-Wi} that now dominates in potato production areas in the U.S. Deployment of *Ry* genes conferring broad, extreme, strain non-specific resistance to PVY (ER) seems a more acceptable strategy over the long run, provided such genes have reliable, stable, and predictive genetic markers and are confirmed to withstand all currently known strains of PVY. In our experiments, Payette Russet was fully resistant to all nine tested PVY strains and four additional genetic variants of the virus (Table 2). This suggested that the *Ry_{sto}* resistance gene present in the genome of Payette Russet indeed conferred an ER against 18 isolates of PVY maintained in our PVY collection. These tested isolates of PVY represented all genetic diversity of PVY found so far in the U.S., and thus Payette Russet may be deemed fully PVY-resistant or completely immune to PVY within the boundaries of the U.S. or even in North America

CONCLUSIONS:

- Payette Russet potato was found completely resistant to nine strains and four genetic variants of PVY
- *Ry_{sto}* gene appears to provide broad resistance against PVY strains
- Payette Russet represents an excellent parent for potato breeding programs