

# Introgression of *Globodera* Resistance into the Russet Market Class

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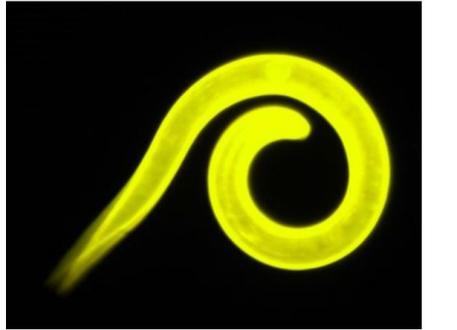
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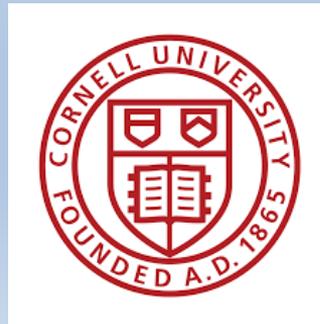
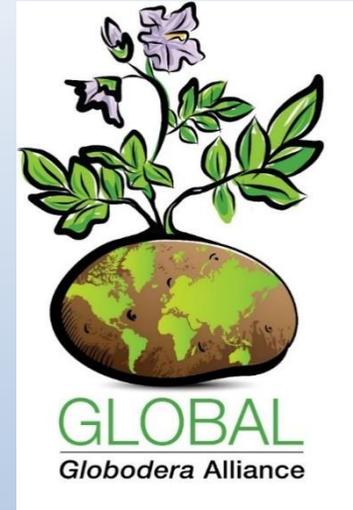
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<sup>5</sup>USDA-ARS, Ithaca, NY



Potato cyst nematode (*Globodera pallida*) with florescent stain (PKH26) observed under the microscope (R Kooliyottil)

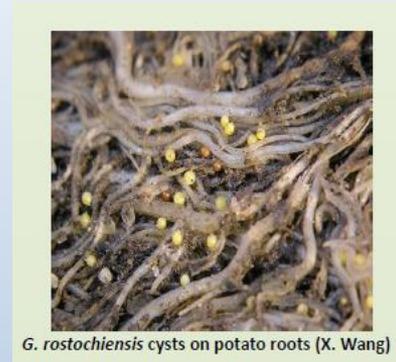


University  
of Idaho

# PCN History in North America

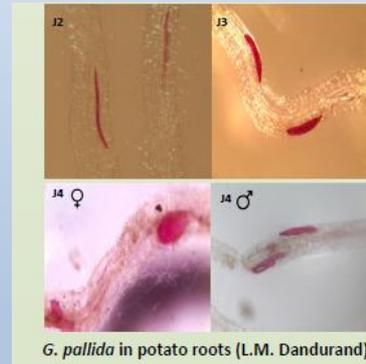
*G. rostochiensis* (Quarantined) [aka Golden]

- First detected on Long Island, NY
  - ✓ Symptoms evident since late 1930s
- 2006: Detected in Quebec



*G. pallida* (Quarantined) [aka Pale]

- 2006: Detected in Idaho



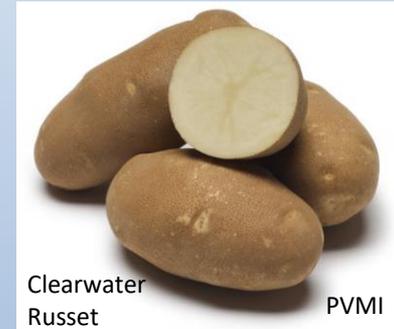
*G. ellingtonae* (Not quarantined)

- 2008: Oregon and Idaho



# Following the Discovery of *G. pallida* in Idaho

- Assess germplasm present in Aberdeen breeding program for PCN resistance
  - ✓ 9 cultivars (European & New Zealand)
  - ✓ 13 breeding lines (Nematode resistance in pedigree)
  - ✓ Susceptible controls: Desiree & Russet Burbank
- Challenged with 3 *Globodera* species: Replicated trials in bio-secure facilities
  - Idaho (Dandurand)– *G. pallida* (Pa2/3)
  - New York (Wang) – *G. rostochiensis* (Ro1)
  - Oregon (Zasada) – *G. ellingtonae*
- 4-6 pots per cultivar/breeding line
- Standardized by calculating relative susceptibility to cv. Desiree
- Whitworth et al. *Resistance of Potato Breeding Clones and Cultivars to Three Species of Potato Cyst Nematode*. Plant Disease “First Look”
- Use PCN-resistant clones in hybridizations to long, russet-skinned parents
- Develop PCN-resistant germplasm with desired long tuber type & russet skin



# Screening Results

- Higher levels of resistance to *G. ellingtonae* and *G. rostochiensis* than to *G. pallida*
- Similar correlated resistance response to *G. rostochiensis* and *G. ellingtonae*—*H1* being possible gene candidate
- NY 121, Sante, Eden, and Moonlight:
  - MR to *pallida*
  - HR to *rostochiensis* and *ellingtonae*

Breeding line/cultivar	<i>G. pallida</i>	<i>G. ellingtonae</i>	<i>G. rostochiensis</i>	average
NY 121	6.5	9	9*	8.2
Sante	6	9	8.5*	7.8
Eden	5	9	9*	7.7
Moonlight	5.5	9	8.5*	7.7
Albatros	2.5	9	9*	6.8
Avondale	3	9	8*	6.7
Karaka	5.5	9	5.5*	6.7
Nicola	2	9	9*	6.7
Slaney	2.5	9	7.5*	6.3
Banba	1	9	8*	6.0
V-15-71	3	3	9*	5.0
A03882-10YN	4.5	3.5	6*	4.7
A08636-7PCN	4.5	3	6	4.5
A03873-3	3.5	6.5	2.5*	4.2
A08636-8PCN	2.5	3	5.5*	3.7
A08640-8	3	4.5	3	3.5
A06968-4	3	3	4	3.3
A08640-2	3	3.5	3	3.2
A061008-4	3	3.5	2.5 <sup>nt</sup>	3.0
A06689-2	2	2.5	3.5	2.7
A07934-7	2.5	3.5	2	2.7
A08636-11PCN	2.5	2	3.5*	2.7
Désirée	2	2	2	2.0
Russet Burbank	2	2	2	2.0
<b>Average</b>	<b>3.4</b>	<b>5.6</b>	<b>5.7</b>	

\* indicates presence of H1 marker 57R and/or TG689  
<sup>nt</sup> not tested for markers

**Table 1** Standard scoring notation

Relative susceptibility (%)	Score
< 1	9
1.1–3	8
3.1–5	7
5.1–10	6
10.1–15	5
15.1–25	4
25.1–50	3
50.1–100	2
> 100	1

A score of 9 indicates the maximum level of resistance.

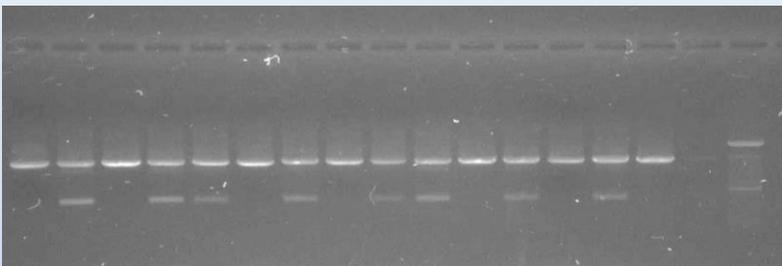
# Eden x Western Russet: A10915 Population

- Family generated in 2010 @ Aberdeen
- TPS germinated *in vitro*: 251 plantlets-Kuhl
- Screened with molecular markers-Kuhl



Gene	Resistance to:	Molecular Marker	Position
<i>H1</i>	<i>G. rostochiensis</i> Ro1 and Ro4	57R	Chr. V distal end
<i>GPaIV<sup>s</sup><sub>adg</sub></i>	<i>G. pallida</i>	Contig237	Chr. IV
<i>Gpa5</i>	<i>G. pallida</i>	HC	Chr. V

# Molecular Markers for *Globodera* resistance: A10915



Molecular marker 57R for detection of H1 gene

PCN Resistance Genes/Loci:	<u><i>GpaIV<sup>s</sup><sub>ada</sub></i></u>	<i>Gpa5</i>	<i>Gpa2</i>	<i>H1</i>
Associated Markers:	<u>Contig 237</u>	HC	221R	57R
<b>Parents</b>				
Eden	+	-	+	+
Western Russet	-	-	-	-
<b>Reference Potato Varieties</b>				
Russet Burbank	-	-	-	-
Innovator	-	+	-	+
<u>Tokio</u>	+	+	+	+

Molecular Marker Segregation in Family A10915	Present	Absent	Undetermined
<u>Contig 237</u> associated with <u><i>GpaIV<sup>s</sup><sub>ada</sub></i></u>	118	116	17
57R associated with H1	194	50	7

⇒ Eden: Simplex for *GpaIV<sup>s</sup><sub>ada</sub>*

⇒ Eden: Duplex for *H1*

# Eden x Western Russet: A10915 Population

- Tubers produced in greenhouse at Aberdeen in 2016 from TC plantlets
- Progeny in the field at Aberdeen-2017
  - ✓ 224 progeny and parents
  - ✓ Agronomic selection
  - ✓ Marker data used while selecting
  - ✓ 31 selected (14%)
  - ✓ 30 progeny with marker data available





Eden: Resistant

Western Russet:  
Susceptible



## Marker Summary of Selected Progeny

Total # of Progeny	<i>H1</i>	<i>Gpa1VS<sub>adg</sub></i>	BOTH
30	25	20	16



A10915-41

Both progeny had the two markers associated with resistance to PCN from Eden



A10915-71

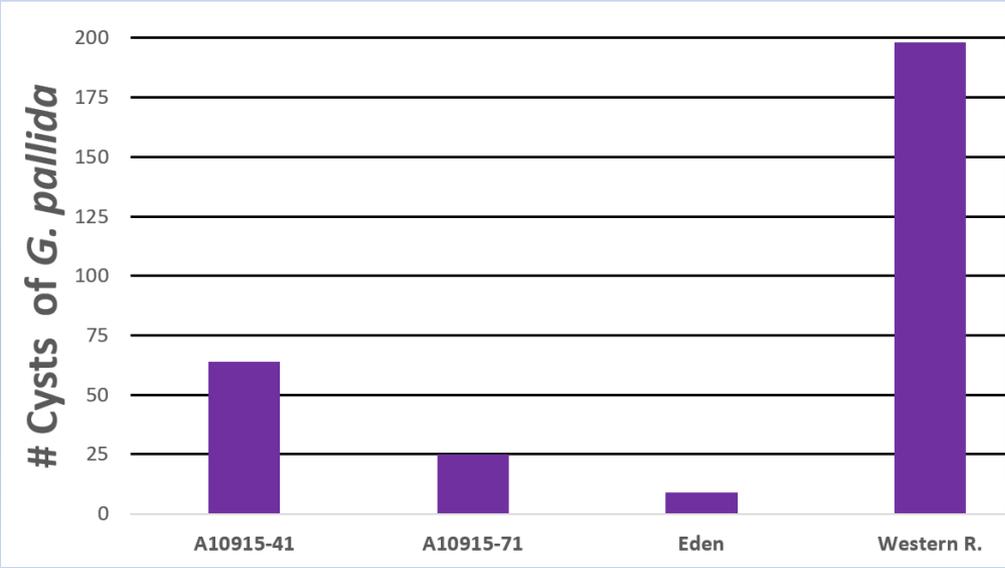
# PCN Screenings by Nematologists



Resistant to *G. ellingtonae* with no cysts like Eden; whereas average of 14 cysts for Western Russet



Average number of cysts of *G. pallida* in greenhouse challenges (2016 & 2017)



Six replicates of each clone were challenged in each of the 2 years

# Processing Evaluations: 2017 Field Season



Stored at 45°F for 3 months

# Pyramiding of PCN Resistance Genes

- Pyramiding of resistance loci has been shown to enhance overall resistance to PCN
- Hybridizations of A10915 progeny ( $Gpa1VS_{adg}$ ) with 10 European cultivars and 2 breeding clones having  $Gpa5$  were conducted in the spring of 2018
  - 31 families generated
- In segregating hybrid progeny with  $Gpa5$  and  $Gpa1VS_{adg}$  increased resistance to *G. pallida* is anticipated:

*We demonstrated that individuals carrying both QTLs showed a significant reduction in the number of cysts formed in comparison to genotypes carrying  $Gpa1VS_{adg}$  or  $Gpa5$ , indicating an additive effect.*

Dalton et al. 2013

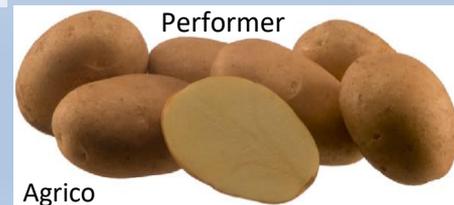
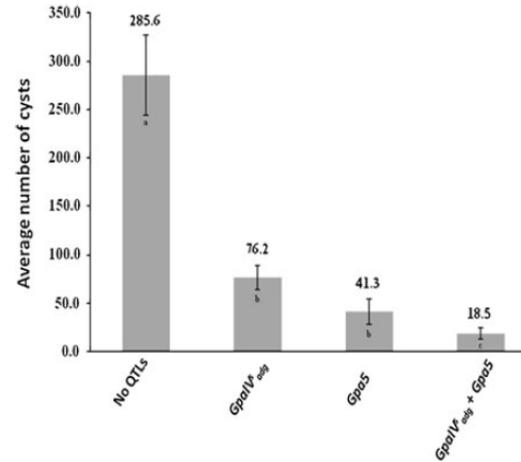
Mol Breeding (2013) 31:921–930  
DOI 10.1007/s11032-013-9845-9

The effect of pyramiding two potato cyst nematode resistance loci to *Globodera pallida* Pa2/3 in potato

Emmet Dalton · Denis Griffin ·  
Thomas F. Gallagher · Nick de Vetten ·  
Dan Milbourne



Mol Breeding (2013) 31:921–930



# Eden x Western Russet (A10915) – future work

- Analysis of 234 progeny with potato SNP chip V3 (22,000 markers)
- Associate SNPs with *G. pallida* resistance
  - Identify additional genetic loci associated with resistance
- Additional resistance loci will be used to enhance resistance from *GpaIVS<sub>adg</sub>*

# Summary

- PCN-resistant hybrids of Eden x Western Russet were obtained
  - Exhibited desired tuber characteristics of russeted skin and long shape
  - Several progeny with acceptable fry processing attributes
- MAS selection for PCN-resistance genes employed and useful during field selection
- A10915 progeny having PCN-resistance were successfully hybridized: Spring 2018
  - European & New Zealand varieties, and breeding clones having *G. pallida* resistance
- Pyramiding of *Gpa1VS<sub>adg</sub>* and *Gpa5* in hybrid populations of A10915 x European varieties and breeding clones
  - Greater resistance to *G. pallida* anticipated based on published data from Dalton et al. 2013
- Future: Identification of additional QTLs for *G. pallida* resistance in A10915 progeny using SNP chip V3
- PCN-resistant russet varieties suitable for OR and ID growers can be a component of an integrated approach for PCN management/eradication

# Financial Support for Research

- **USDA-NIFA Food Security Grant: Risk Assessment and Eradication of *Globodera* spp. in US Production of Potato**
  - Known as the “GLOBAL Project” for *Globodera* Alliance
  - 17 scientists, 8 institutions; U.S. Canada, Scotland, France
- **ISDA Specialty Crop Block Grant: *Development of Pale Cyst Nematode resistance in russet-skinned potato clones for Idaho***

**THANK YOU!  
QUESTIONS?**

