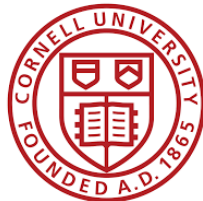


# Use of Molecular Markers for Breeding PCN Resistance in the Russet Market Class

Joe Kuhl - University of Idaho  
Louise-Marie Dandurand - University of Idaho  
Richard Novy - USDA-ARS, Aberdeen  
Jonathan Whitworth - USDA-ARS, Aberdeen  
Inga Zasada – USDA-ARS, Corvallis  
Walter DeJong - Cornell University  
Xiaohong Wang - USDA-ARS, Ithaca

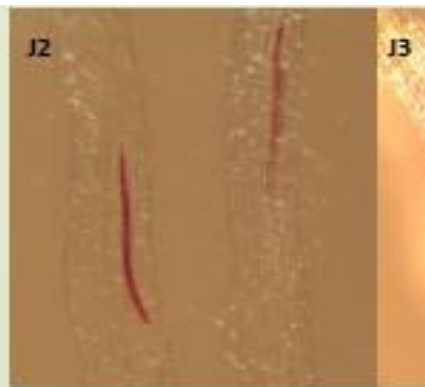


**University of Idaho**  
College of Agricultural  
and Life Sciences





*G. ellingtonae* cyst on potato root (I. Zasada)



*G. pallida* in potato roots (L.M. Dandurand)



*G. rostochiensis* cysts on potato roots (X. Wang)

# Potato Cyst Nematode U.S. History

- *G. rostochiensis* (quarantined) [aka Golden]
  - first detected on Long Island, NY, USA. Symptoms evident since late 1930s
- *G. pallida* (quarantined) [aka Pale]
  - Idaho, USA detected in 2006
- *G. ellingtonae* (not quarantined) [aka unnamed]
  - Oregon and Idaho, USA detected in 2008

# Objectives

- Identify potato cyst nematode resistance to multiple species
- Use results to develop populations for further resistance work
- Develop oblong russets with nematode resistance for the western market

# Overview of PCN Resistance

- **14 loci (genes) mapped to eight different chromosome regions**
- **Derived from multiple relatives of cultivated potato**

## ***G. rostochiensis* (Golden cyst)**

- Major gene, *H1*, confers complete resistance to primary pathotypes (Ro1 and Ro4)
- Discovery in 1952 from *S. tuberosum* ssp. *andigena*
- Mapped to chromosome 5 and marker identified to aid in selection
- Present in many commercial varieties

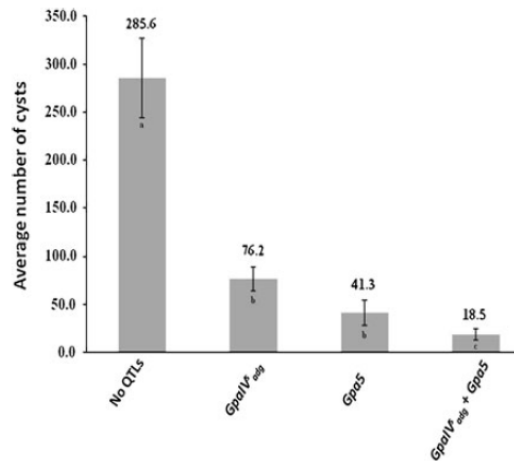
## ***G. ellingtonae***

- *H1* also appears to be associated with conferring resistance to *G. ellingtonae*

## ***G. pallida* (Pale cyst)**

- More complicated resistance-polygenic
- Major contributing resistance gene (*Gpa5*) found on chromosome 5; marker also associated with it
- *Gpa1V<sup>s</sup><sub>adg</sub>* as well with associated molecular marker
- Additional genes as well contributing, although the two above are primary sources of *pallida* resistance currently in cultivars

Mol Breeding (2013) 31:921–930



# Aberdeen Program: PCN-Resistant Varieties/Breeding Clones Used as Parents (Emphasis on *G. pallida*-resistance)

## European

- Sante (NL)
- Eden (UK)



## New Zealand

- Moonlight
- **Karaka**
- Bondi



## South America

- Maria Huanca



## Cornell University

- NY 121



# Aberdeen Program:

## PCN-Resistant Varieties/Breeding Clones Used as Parents

(Emphasis on *G. pallida*-resistance)

Dutch

**Agrico**

- Alicante
- Ambassador
- Arsenal
- Basin Russe
- Nomade
- Performer
- Producent

**HZPC**

- Innovator



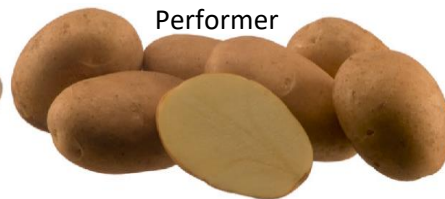
Alicante



Arsenal



Basin  
Russet



Performer



Innovator

HZPC



Nomade

German

**Norika**

- Nautilus
- Tokio



Nautilus



Tokio

**Europlant:**

**Ivetta**



Ivetta

# Populations

- Eden x Western Russet
  - A10915, 234 progeny
  - Resistance from *S. tuberosum* ssp. *andigena*
- Bill Brodie, Robert Plaisted, Maria Scurrah
  - Brodie et al. 1991; Brodie et al. 2000
  - NYW69, 72 and 73 populations submitted to NRSP-6 in 2000
  - Resistance from *S. tuberosum* ssp. *andigena* and *S. vernei* (International Potato Center)

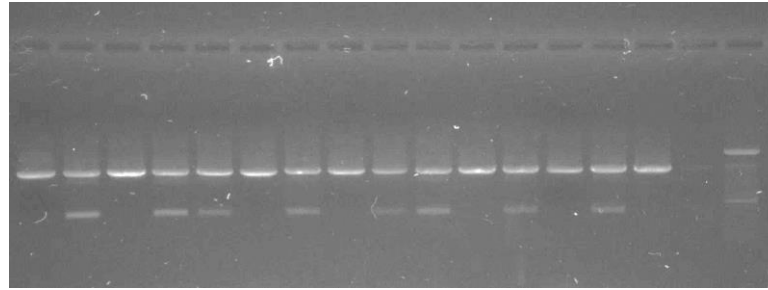


# Molecular Markers for Resistance

Gene/ Locus	Resistance	Source	Molecular Marker	Position	Marker Reference
<i>H1</i>	Ro1,4	adg	57R	Chr. V	Milczarek et al. '14
<i>Gro1-4</i>	Ro1	spg	Gro1-4 SCAR	Chr. VII	Paal et al. '04
<i>GpaIV<sub>adg</sub></i>	Pa2,3	adg	Contig237	Chr. IV	Moloney et al. '10
<i>Gpa5</i>	Pa2,3	ver	HC	Chr. V	Dalton et al. '13
<i>Ro2</i>	Ro2, Pa2,3	ver	SPUD 5000	Chr. V	Per. comm. WDJ
<i>Gpa5</i>	Pa2,3	ver	SPUD 1636	Chr. V	Bryan et al. '02
<i>Gpa2</i>	Pa2,3	adg	221R	Chr. XII	Kanyuka et al. '00

# Molecular Markers

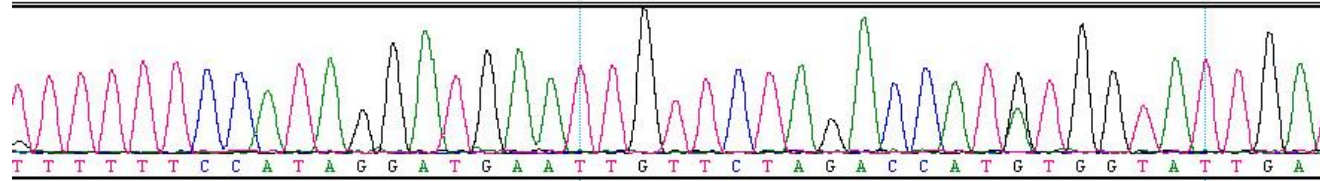
PCR-based markers: presence/absence



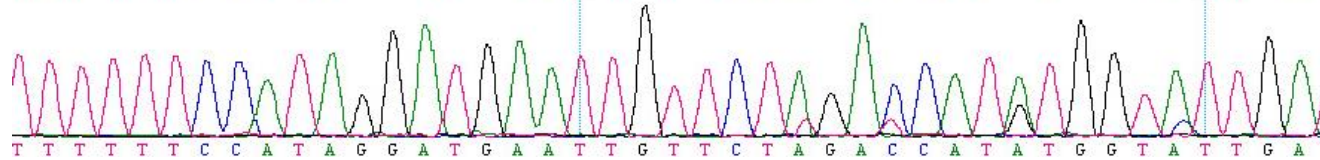
Molecular marker 57R  
for detection of H1  
gene

Sequence detection of contig 237 for detection of *GpaIV<sub>adg</sub>*

Western  
Russet



Eden



# Resistant Cultivars

	<i>H1</i>	<i>Gro1-4</i>	<i>GpaIV<sub>adg</sub></i>	<i>Gpa5</i> (HC)	<i>Ro2</i>	<i>Gpa5</i> (1636)	<i>Gpa2</i>
Eden	+	-	+	-	-	-	+
Nicola	+	-	+	-	-	-	+
Alicante	-	-	-	+	+	-	+
Ambassador	-	-	-	+	+	-	-
Arsenal	-	-	-	+	+	+	-
Basin Russet	-	-	-	+	+	-	-
Nomade	-	-	-	+	+	-	-
Performer	-	-	-	+	+	+	-
Producent	+	-	-	-	+	+	+
Innovator	-	-	-	+	+	-	-
Nautilus	+	-	-	+	+	-	+
Tokio	+	-	+	+	+	-	+
Moonlight	+	+ (faint)	+	-	-	-	+
Bondi	-	-	+	-	-	-	-
Maria Huanca	-	-	-	-	+	+	+

Molecular  
Markers – for  
A10915  
(Eden x Western  
Russet)

	Chr V	Chr VII	Chr IV	Chr XII
	<i>H1</i>	<i>Gro1-4</i>	<i>GpaIVadg</i>	<i>Gpa2</i>
	57R	SCAR	Contig237	221R
Western Russet	-	+	-	-
Eden	+	-	+	+
A10915-1	+	-	+	+
A10915-3	-	+	+	+
A10915-4	+	-	+	+
A10915-5	+	+	-	+
A10915-6	+	-	+	+
A10915-7	+	+	-	-
A10915-9	+	+	-	+
A10915-10	+	+	-	-
A10915-12	+	+	-	-
A10915-14	+	+	+	+
A10915-15	+	-	-	+
A10915-29	+	+	+	+

# NYW Populations

	<i>H1</i>	<i>Gro1-4</i>	<i>GpaIV<sub>adg</sub></i>	<i>Gpa5</i> (HC)	<i>Ro2</i>	<i>Gpa5</i> (1636)	<i>Gpa2</i>
NYW69-1	+	-	-	+	+	+	-
NYW69-7	+	-	-	+	+	+	+
NYW69-11	+	-	-	+	+	+	+
NYW69-15	+	-	-	+	+	+	+
NYW72-4	+	-	-	+	+	+	+
NYW72-9	-	-	-	+	+	+	+
NYW72-10	+	-	-	+	+	+	+
NYW72-15	-	-	-	+	+	+	+
NYW73-2	+	-	-	-	-	-	+
NYW73-3	-	-	-	+	+	+	+
NYW73-8	+	-	-	+	+	+	+
NYW73-13	+	-	-	+	+	+	+
NY121	+	-	-	-	+	+	+

# Conclusions

- Few cultivars combine *GpaIV<sub>adg</sub>* with resistance loci on chromosome 5
  - Exception: Tokio
- Markers on chromosome 5 suggest that SPUD 5000 is between HC and SPUD 1636
- Few cultivars have all three loci on chromosome 5
  - Exceptions: Arsenal and Performer
- NYW populations contain many of the markers used to track resistance in European cultivars

# Future Work

- Phenotypic responses need to be correlated with marker results
- Additional resistance sources and molecular markers are needed to increase genetic diversity
- New populations could be used to track molecular marker and phenotypic segregation

# Acknowledgements

- Kuhl Lab: Monica Pedroni, Mallory Cullen, Bailey Morris, Chase Jordan, Jon Wait, Hannah Gross, Alex Blackburn, Rocio Silvestre
- PIs and associated labs: Louise-Marie Dandurand, Rich Novy, Jonathan Whitworth, Inga Zasada, Walter De Jong, Xiaohong Wang
- USDA-NIFA Food Security Grant: **Risk Assessment and Eradication of *Globodera* spp. in US Production of Potato**
  - competitive grant no. 2015-69004-23634
- ISDA Specialty Crop Block Grant: **Development of Pale Cyst Nematode resistance in russet-skinned potato clones for Idaho**



**GLOBAL**  
Globodera Alliance