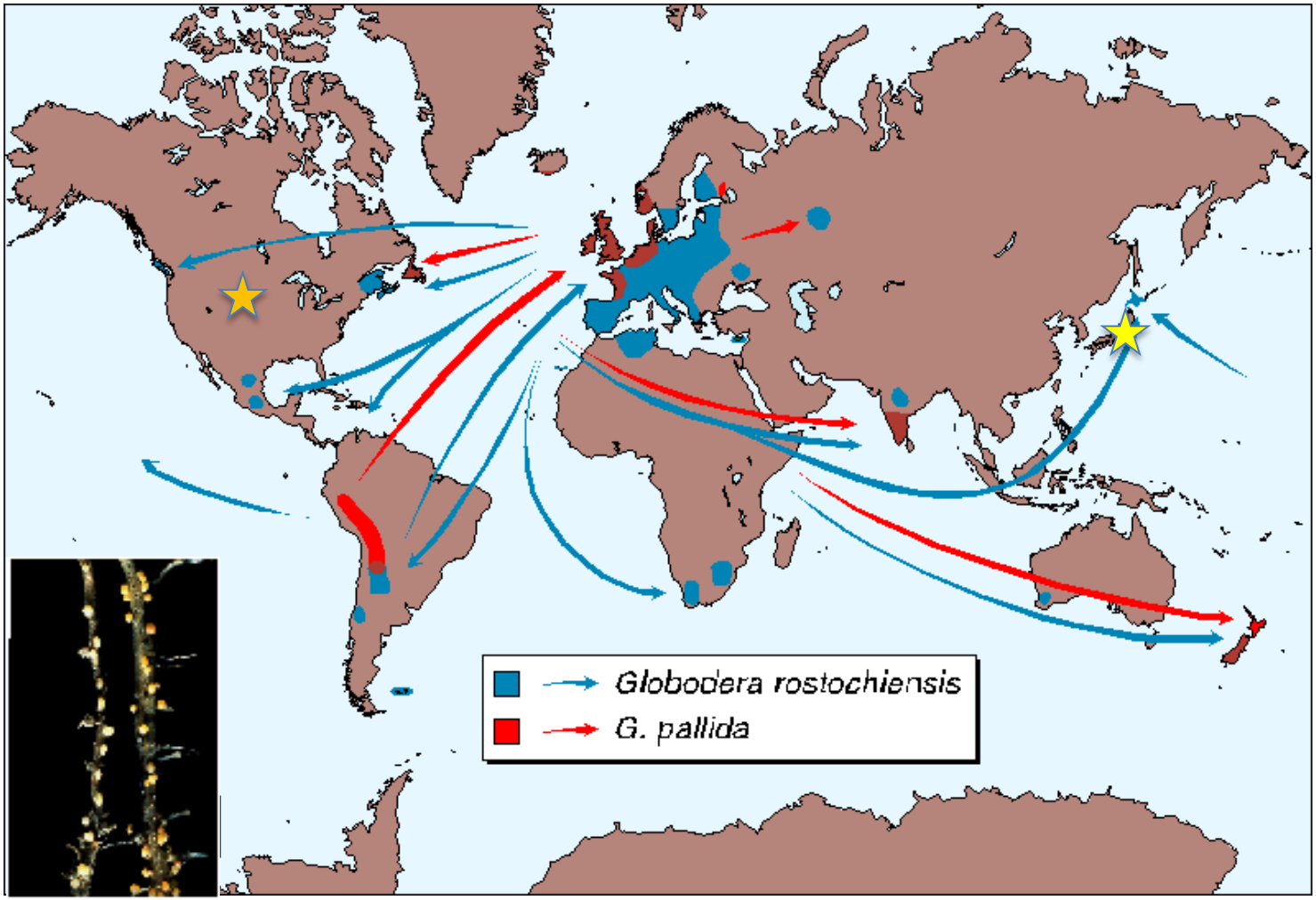
Progress with the PCN problem

The James Hutton Institute

Dr Vivian Blok

Some background to the PCN problem in the UK

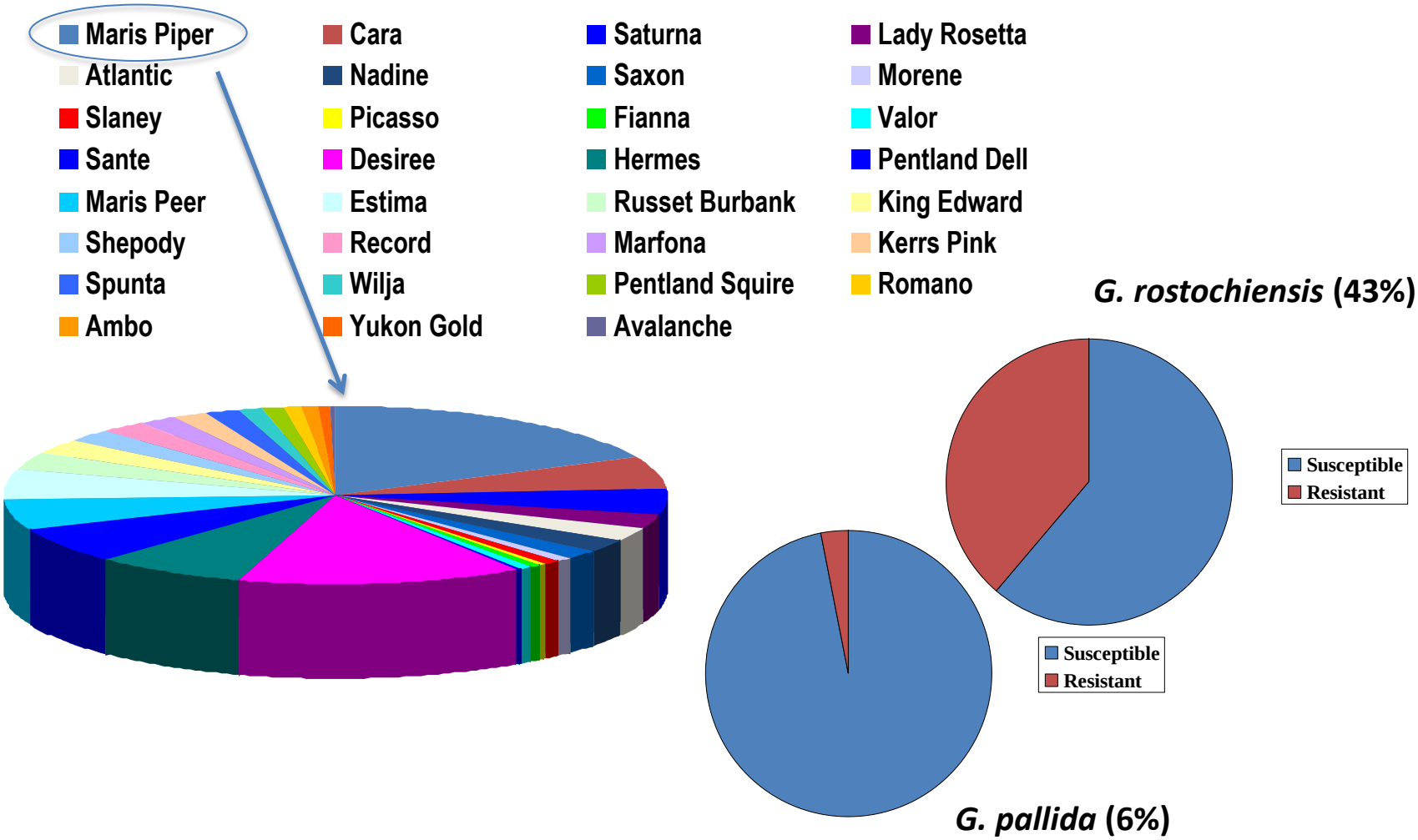
Both *Globodera pallida* and *G. rostochiensis* were introduced from South America into Europe >150 years ago



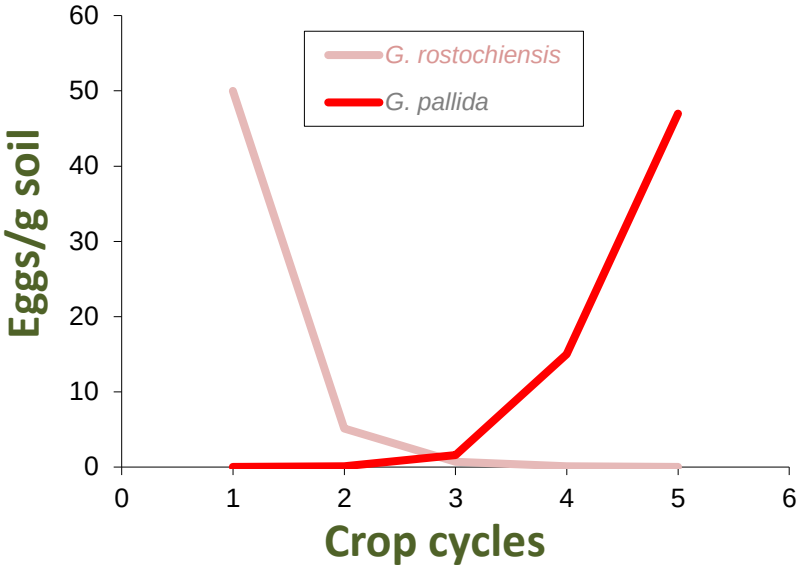
H1 resistance to *Globodera rostochiensis* (Ro1 and 4) from *S. tuberosum* ssp. *andigena* CPC1673 identified in 1952

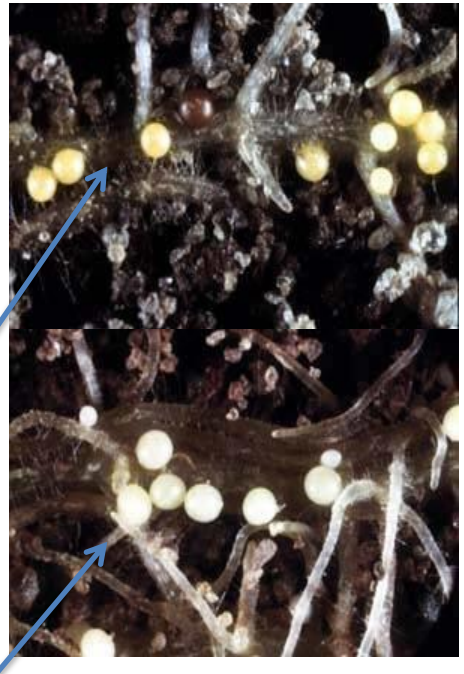
Maris Piper

UK cultivars



H1 resistance impacts PCN species composition

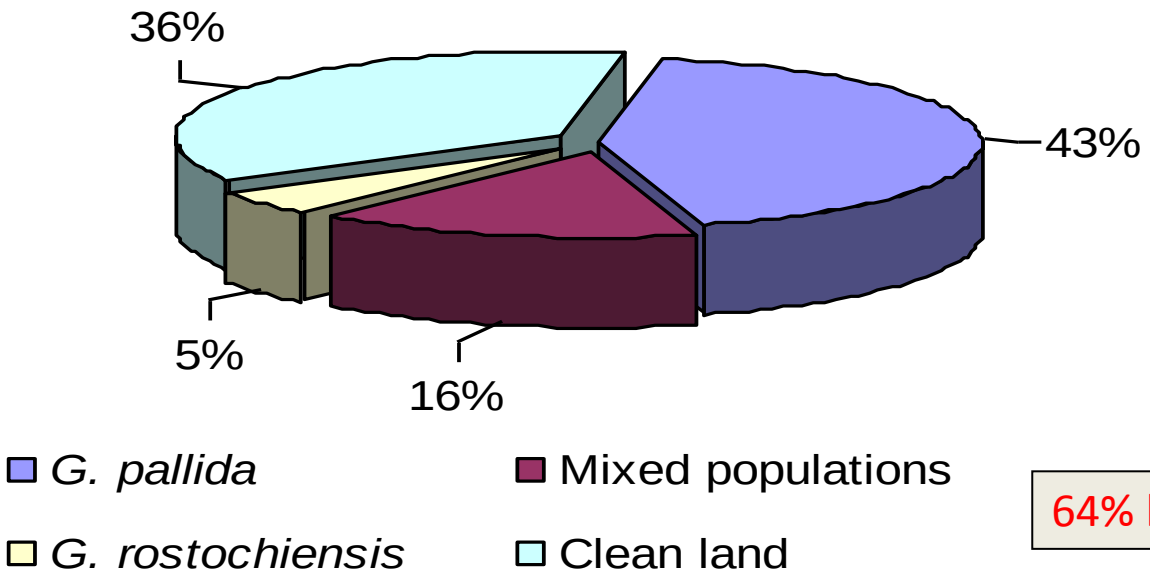




Cultivars with *H1* (ie Maris Piper)

have suppressed *Globodera rostochiensis* and now *G. pallida* is more prevalent

Survey of PCN in England and Wales, 2000

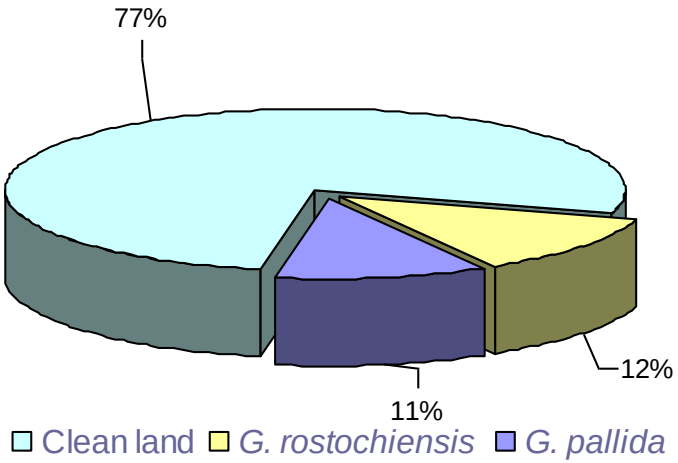


64% land sampled had PCN

Minnis *et al*. (2002) Annals of Applied Biology

Preliminary results of 2014/15 survey: "PCN present in 48% of sites sampled; 43% *G. pallida*, 2% *G. rostochiensis* and 3% contained both species." Kasia Dybal-Lima

PCN in Scotland (SASA data)



In Angus ~40% land PCN +ve

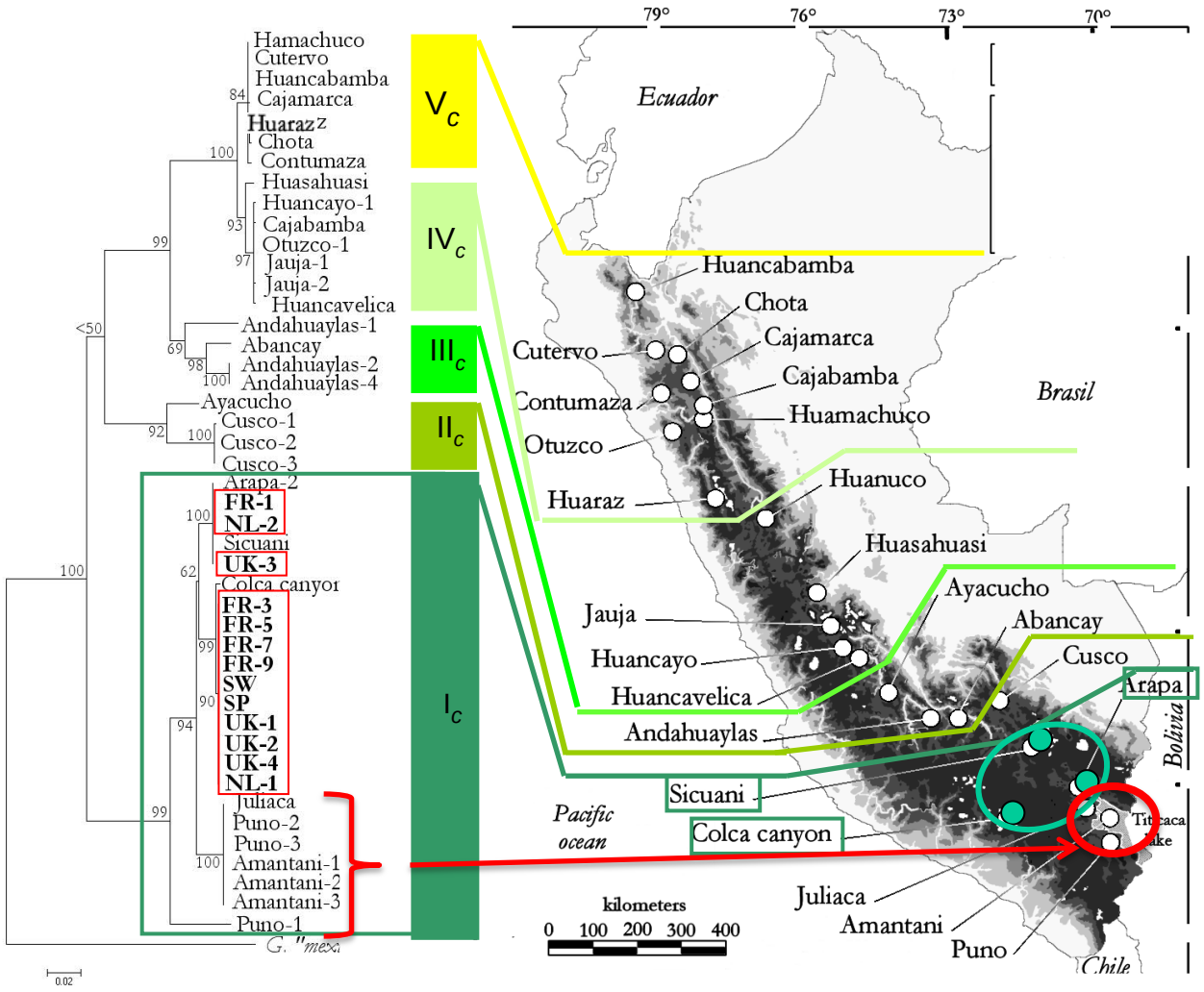
Pathotypes, intraspecific variation and virulence in *G. pallida*

Introductions of PCN in the UK

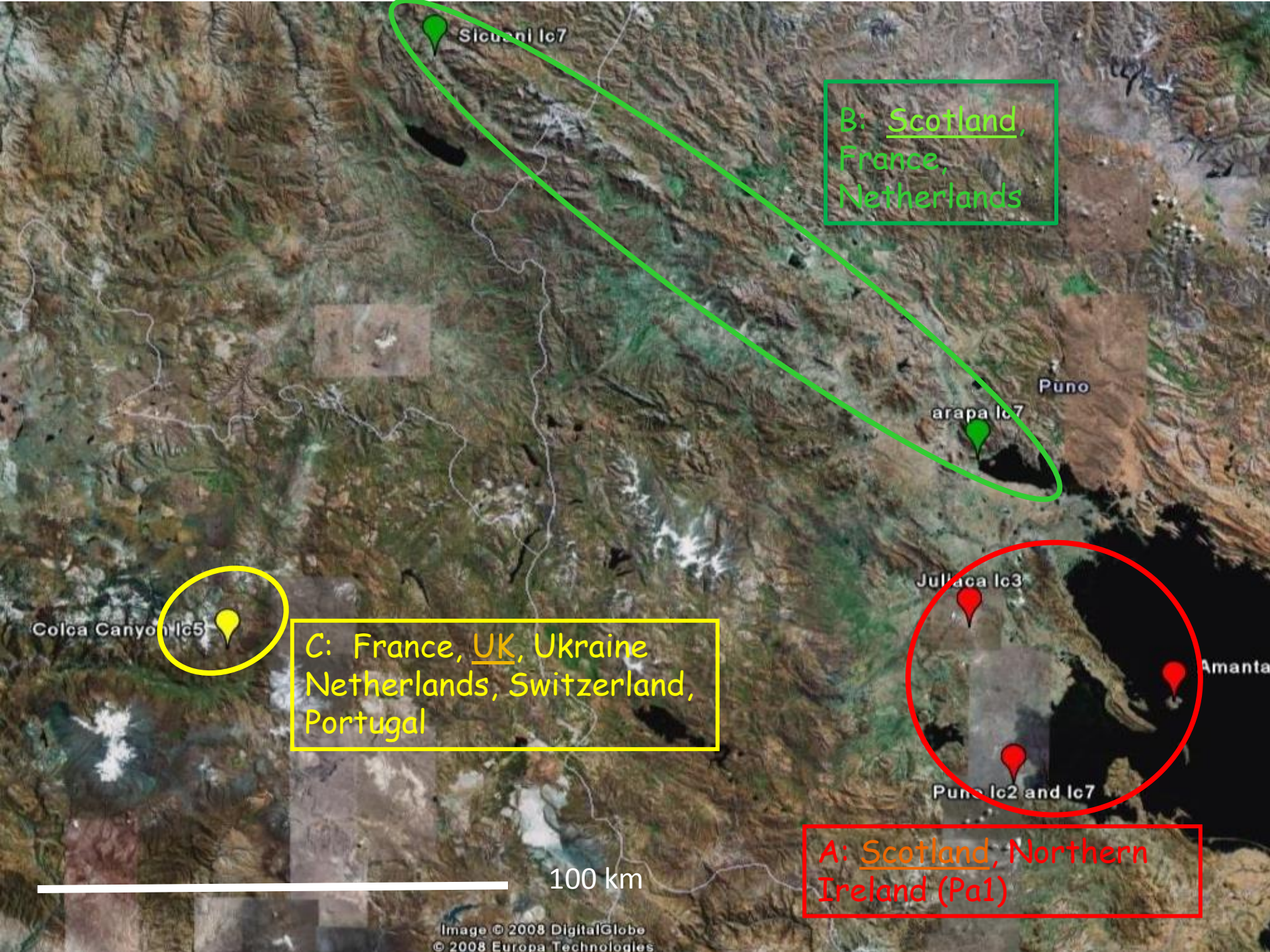
National pathotypes.....		British A Dutch A Hiltrup	Dutch B Obersteinbach	Dutch C	Dutch F	Harmerz	British B	Dutch D	Frenswegen Chavorney Dutch E British E
New pathotypes.....		Ro1	Ro2	Ro3	Ro4	Ro5	Pa1	Pa2	Pa3
Clone	Plant Resistance Code								
S. tuberosum ssp. *tuberosum*		+	+	+	+	+	+	+	+
S. tuberosum ssp. *andigena* CPC 1673 hybr.	Ro1, 4	—	+	+	—	+	+	+	+
S. kurtzianum hybr. 60.21.19	Ro1, 2	—	—	+	+	+	+	+	+
S. vernei hybr. 58.1642/4	Ro1, 2, 3	—	—	—	+	+	+	+	+
S. vernei hybr. 62.33.3	Ro1, 2, 3, 4 Pa1, 2	—	—	—	—	+ —	—	—	+
S. vernei hybr. 65.346/19	Ro1, 2, 3, 4, 5	—	—	—	—	—	+	+	+
S. multidissectum hybr. P 55/7	Pa1	+	+	+	+	+	—	+	+
S. vernei hybr. 69.1377/94	Ro1, 2, 3, 4, 5 Pa1, ,2, 3	—	—	—	—	—	—	—	—

Kort et al 1977 *Nematologica*

Origins of European *G. pallida* populations



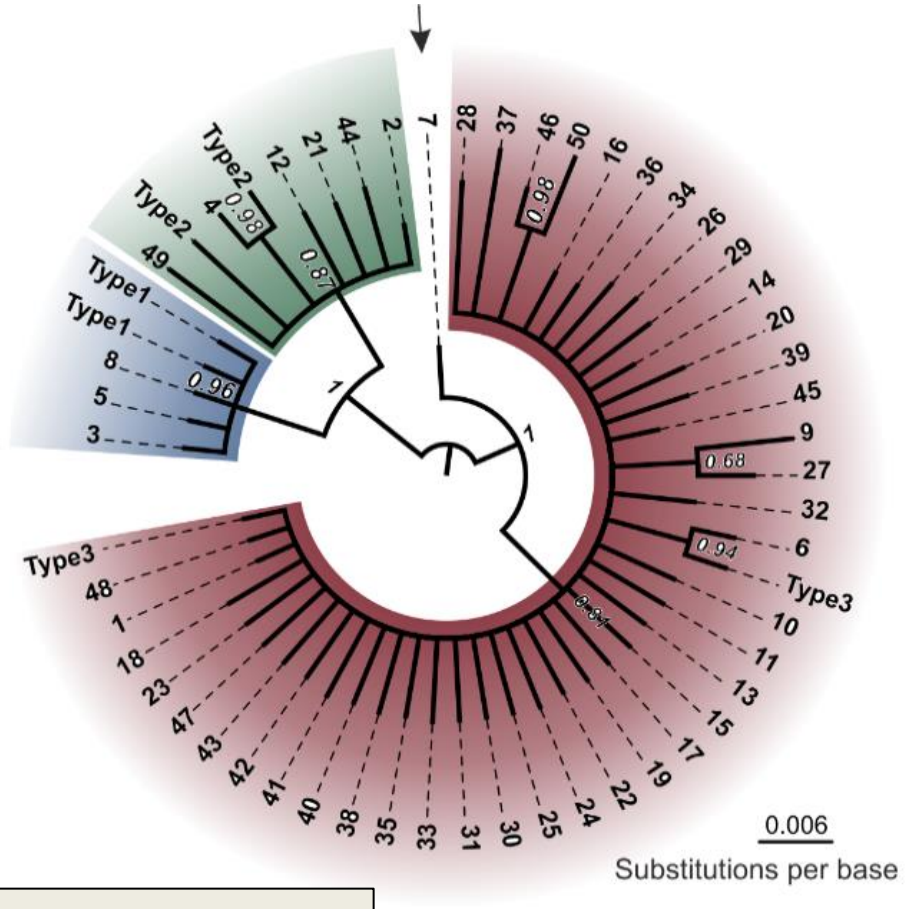
Plantard *et al.* (2008) *Molecular Ecology*


Sicuani lc7
B: Scotland, France, Netherlands
Puno
arapa lc7
Colca Canyon lc5
C: France, UK, Ukraine Netherlands, Switzerland, Portugal
Juliaca lc3
Amanta
Puno lc2 and lc7
A: Scotland, Northern Ireland (Pa1)
100 km
Image © 2008 DigitalGlobe
© 2008 Europa Technologies

Distribution of *G. pallida* variants/introductions in Scotland

- The Science and Advice for Scottish Agriculture (**SASA**) carry out annual preplant Potato Cyst Nematode (PCN) tests – required by EU directive.
- DNA extracted from soil floats, and presence of PCN determined by qPCR
- Annual collections of DNA samples provide a unique resource for monitoring the distribution of PCN and for interrogation of the diversity within the species.

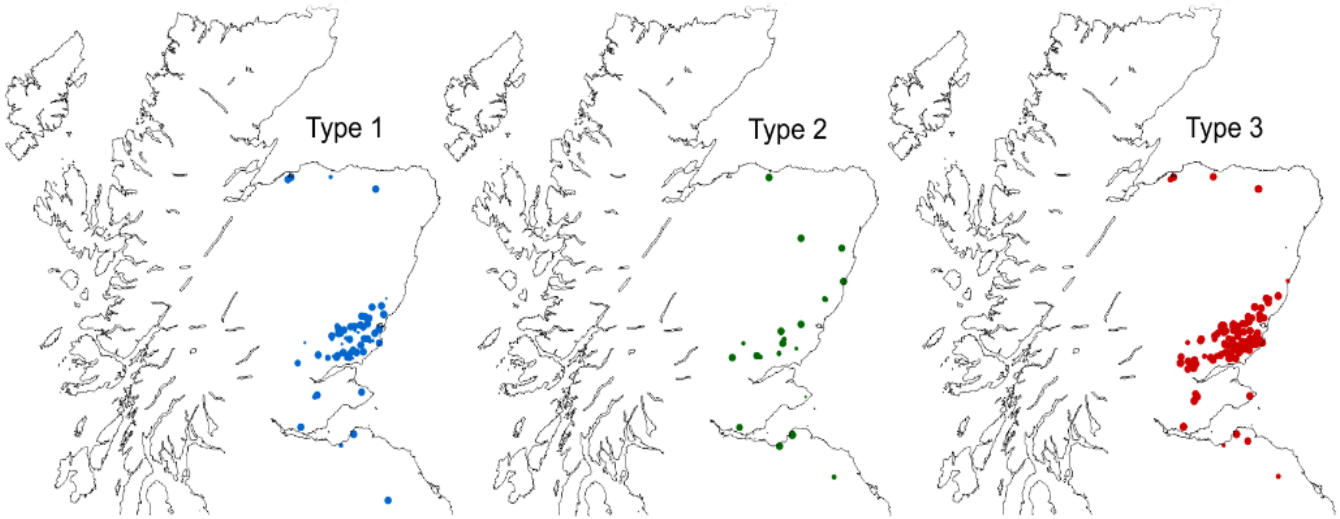
Partial CytB (mtDNA) amplified for ~1000 SASA samples, barcoded, pooled, sequenced and filtered

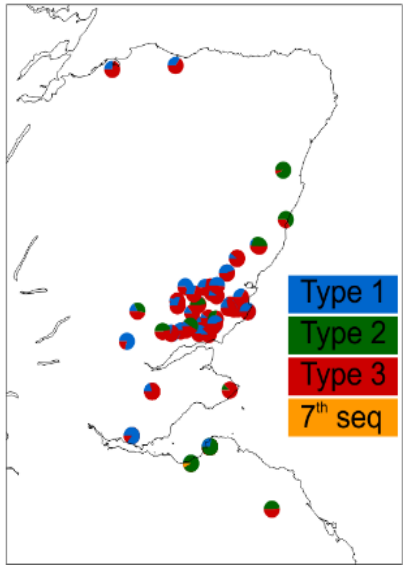


Bayesian phylogeny for top 50 most common types

Eves-van den Akker *et al*. (2015) Molecular Ecology

Occurrence of *G. pallida* introductions in Scotland





- Most fields only have 1 cytB type
- Type 1 and 3 widespread
- 1/5 contain mixtures
- <3% contain all three types
- 1 field has a 4th type

Eves-van den Akker *et al*. (2015) Molecular Ecology

Resistance to *G. pallida:* are we getting there?

New varieties with *G. pallida* resistance

Arsenal

Vales Everest

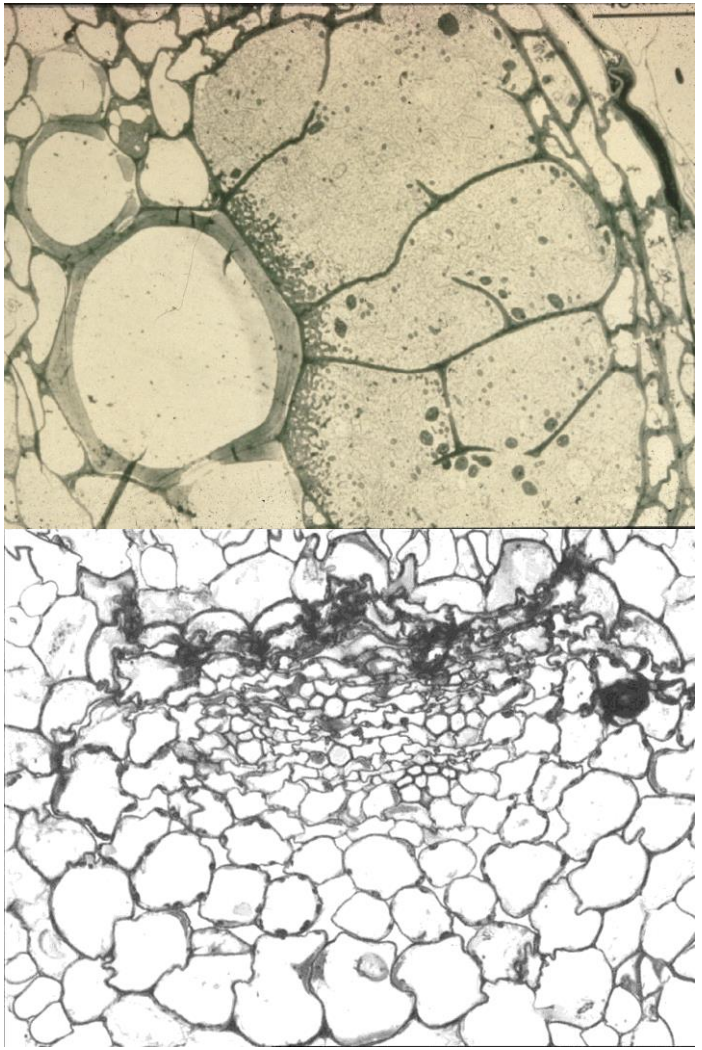
How should we assess durability of resistance to *G. pallida*?

1) Test with *G. pallida* populations in collections

2) Test with *G. pallida* lines selected for virulence

3) Test with new field populations

4) Monitor in the field



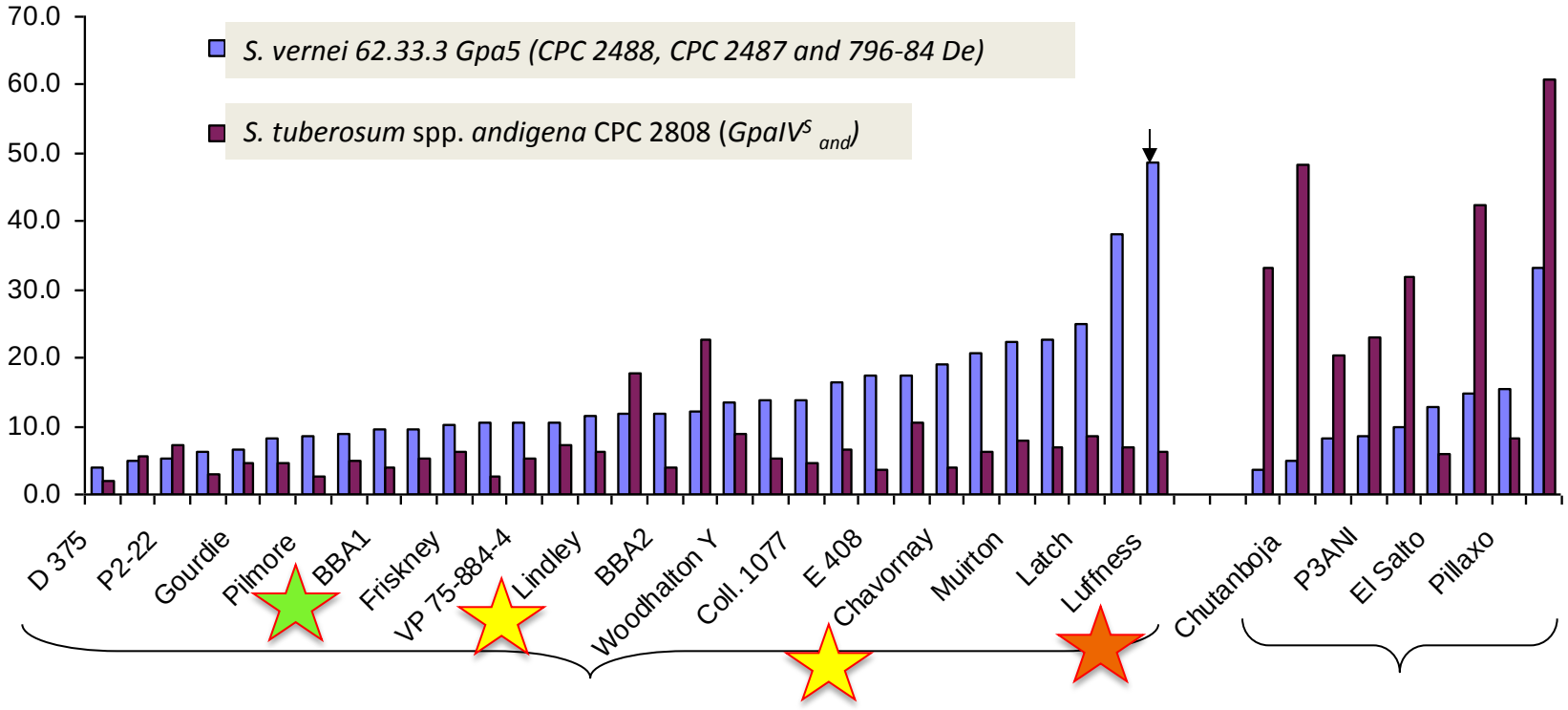
PCN resistance/virulence testing

pots

root trainers

canisters

1) *G. pallida* populations in the JHI collection vary in virulence



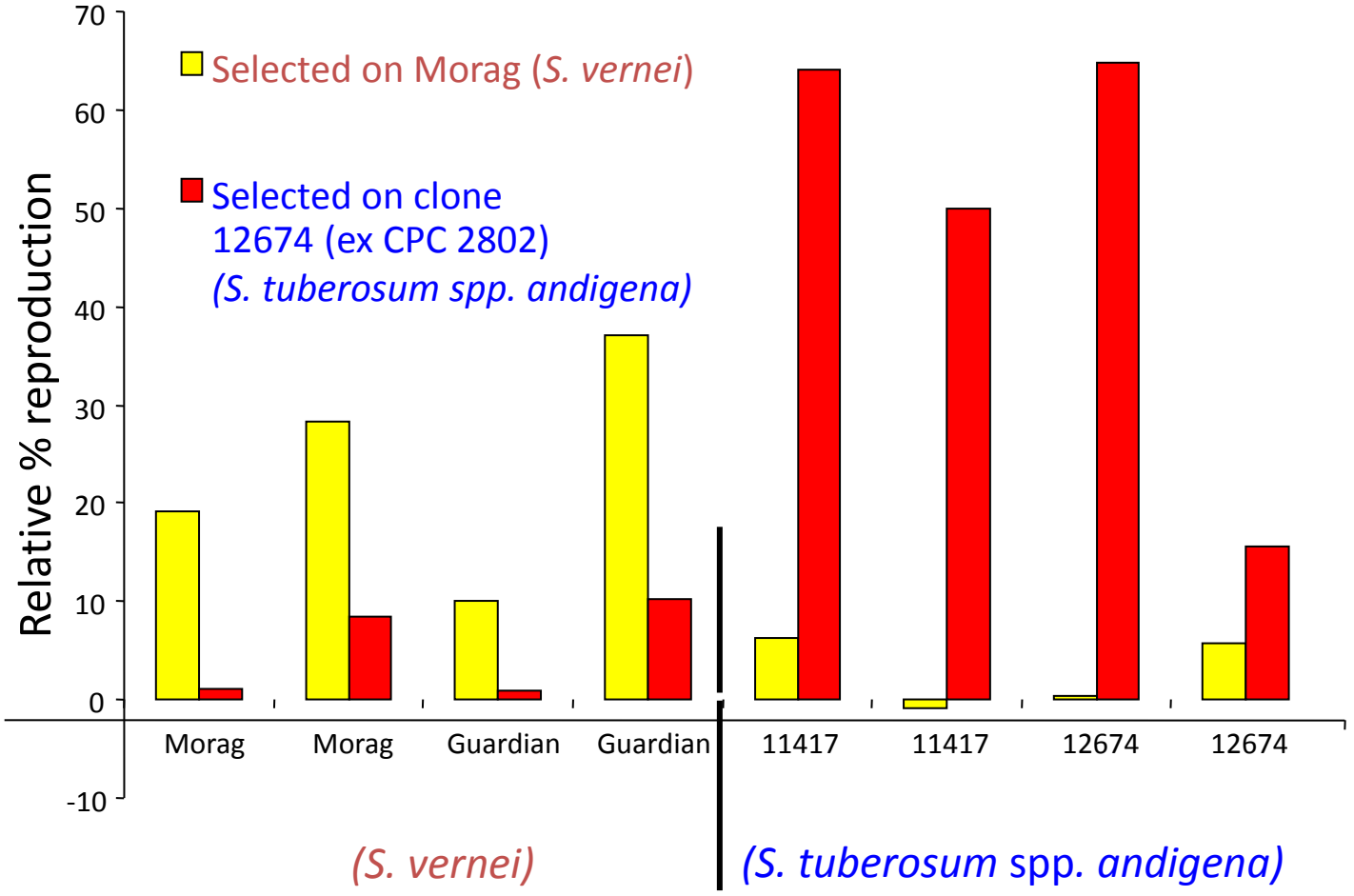
European Pa2/3

Dutch, French, German, UK, Swiss

South American

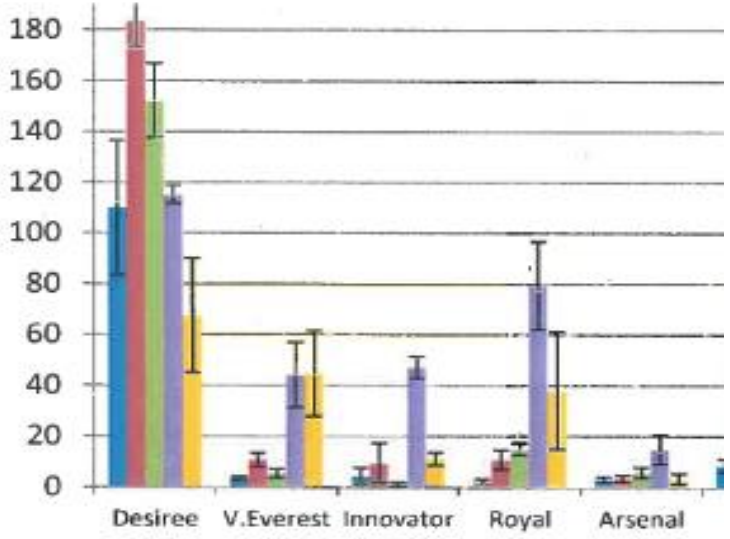
Phillips and Trudgill (1998) *Nematologica*

2) Virulence can increase with repeated multiplication on the same genotype



Phillips and Blok 2008 *Plant Pathology*

2) *G. pallida* lines “selected” for virulence on new varieties

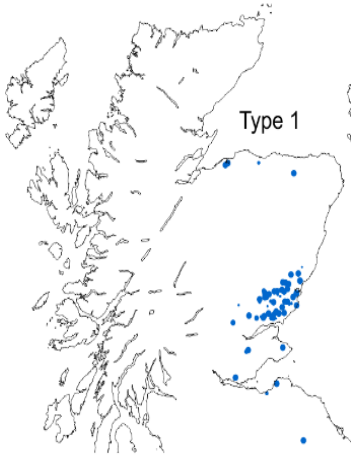


Kyriakos Varypatakis
AHDB PhD student

3) Test with new field populations

Kasia Dybal-Lima
AHDB PhD student

4) Monitor in the field



Pyramiding resistances for durability

Combining GpaIV and Gpa VI reduced multiplication

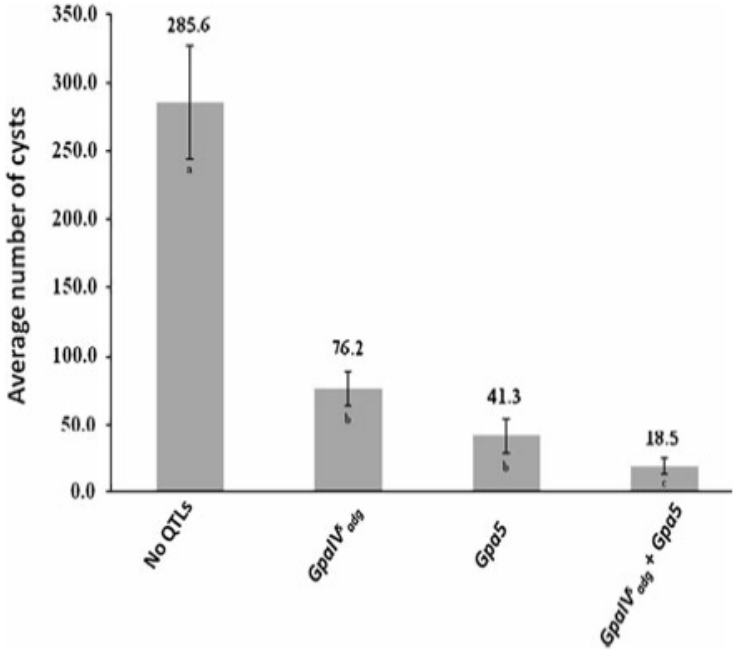
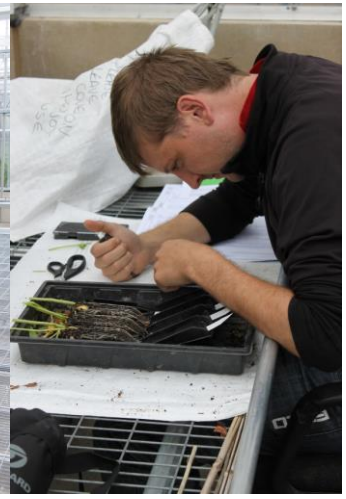


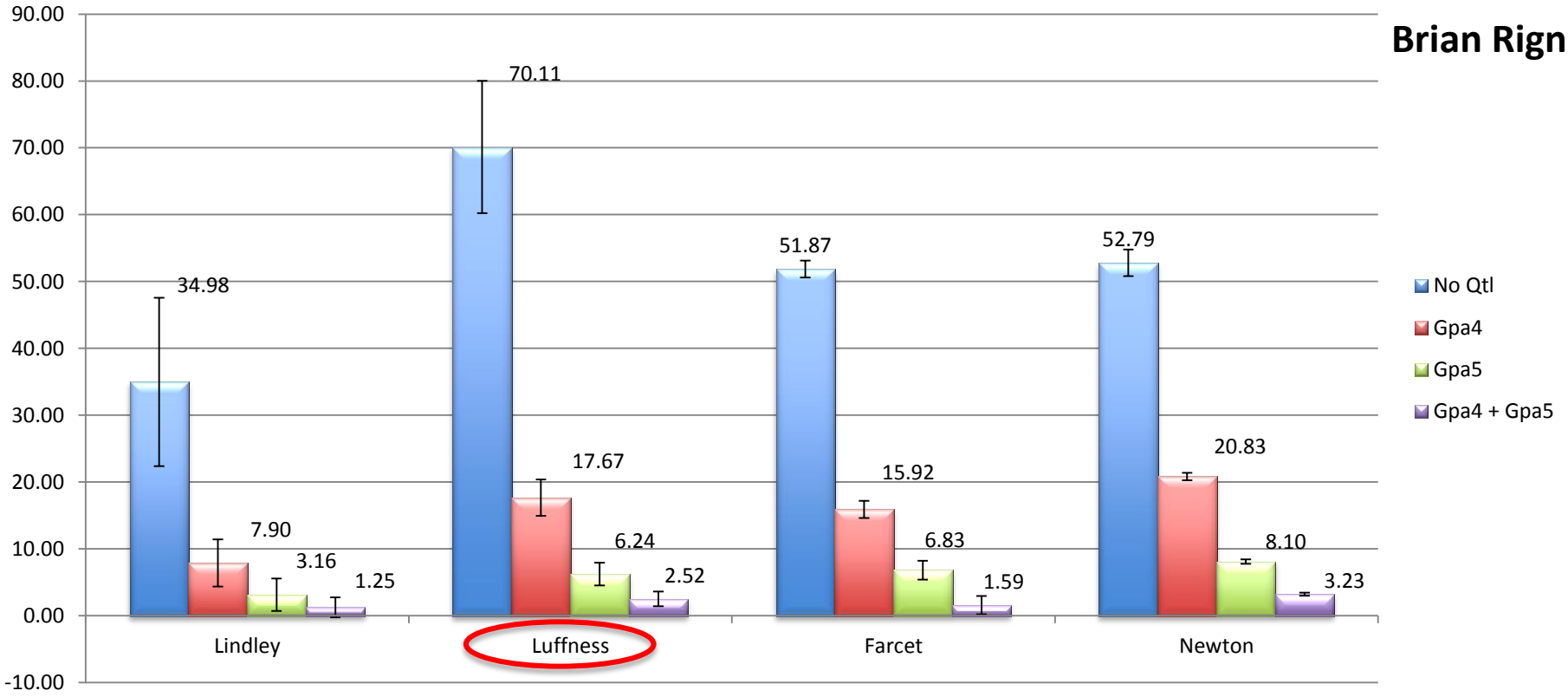
Fig. 2 Mean number of cysts from genotypes carrying different allele combinations of the *GpaIV*$^{s}_{adg}$ and *Gpa5* QTLs. *No QTLs* no resistance allele at both QTL; *GpaIV*$^{s}_{adg}$ resistance allele at *GpaIV*$^{s}_{adg}$ QTL, *Gpa5* resistance allele at *Gpa5* QTL; and *GpaIV*$^{s}_{adg}$ + *Gpa5* resistance alleles at *GpaIV*$^{s}_{adg}$ and *Gpa5*.

Dalton et al 2013 *Molecular Breeding*

More populations tested with pyramided Gpa4 and Gpa5



Brian Rigney



Rigney *et al* 2016 *Plant Pathology* in review

Testing progeny from JHL and commercial breeding programmes pyramiding resistance to *G. pallida*

Xinwei Chen

SASA

Protocol for PCN Resistance Testing – Annex IV

The degree of susceptibility of potatoes to PCN shall be quantified according to the following standard scoring notation.

A score of 9 indicates the highest level of resistance:

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

EPPO Bulletin

Volume 36, Issue 3, pages 419–420, December 2006

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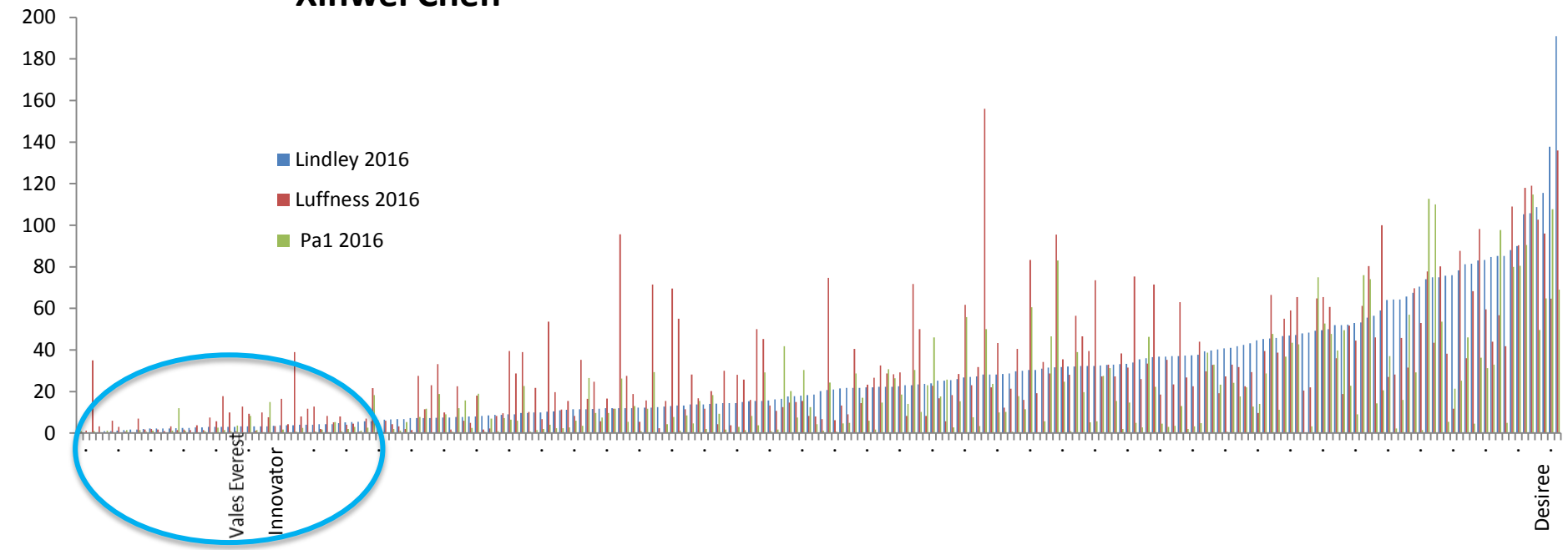
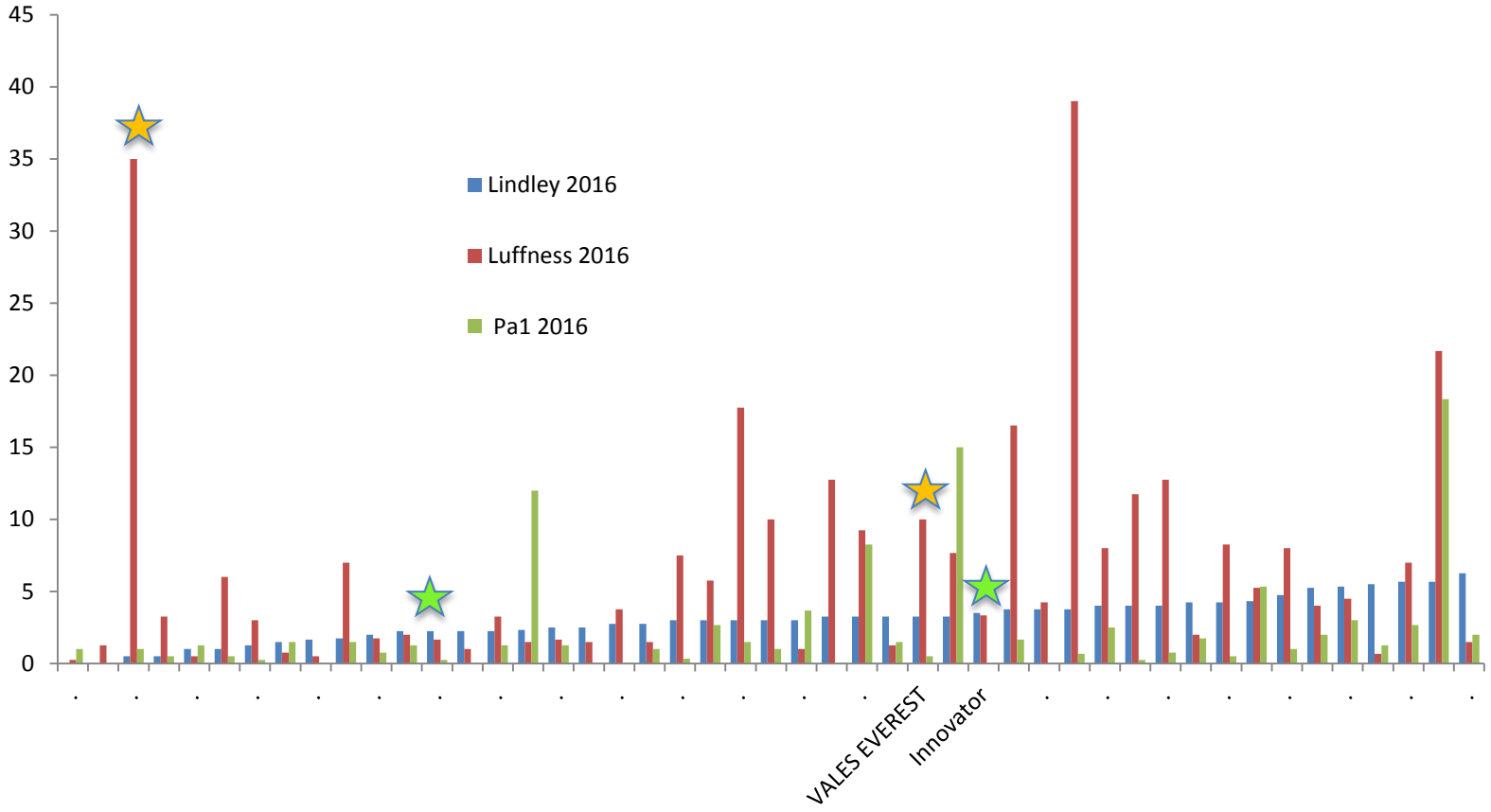
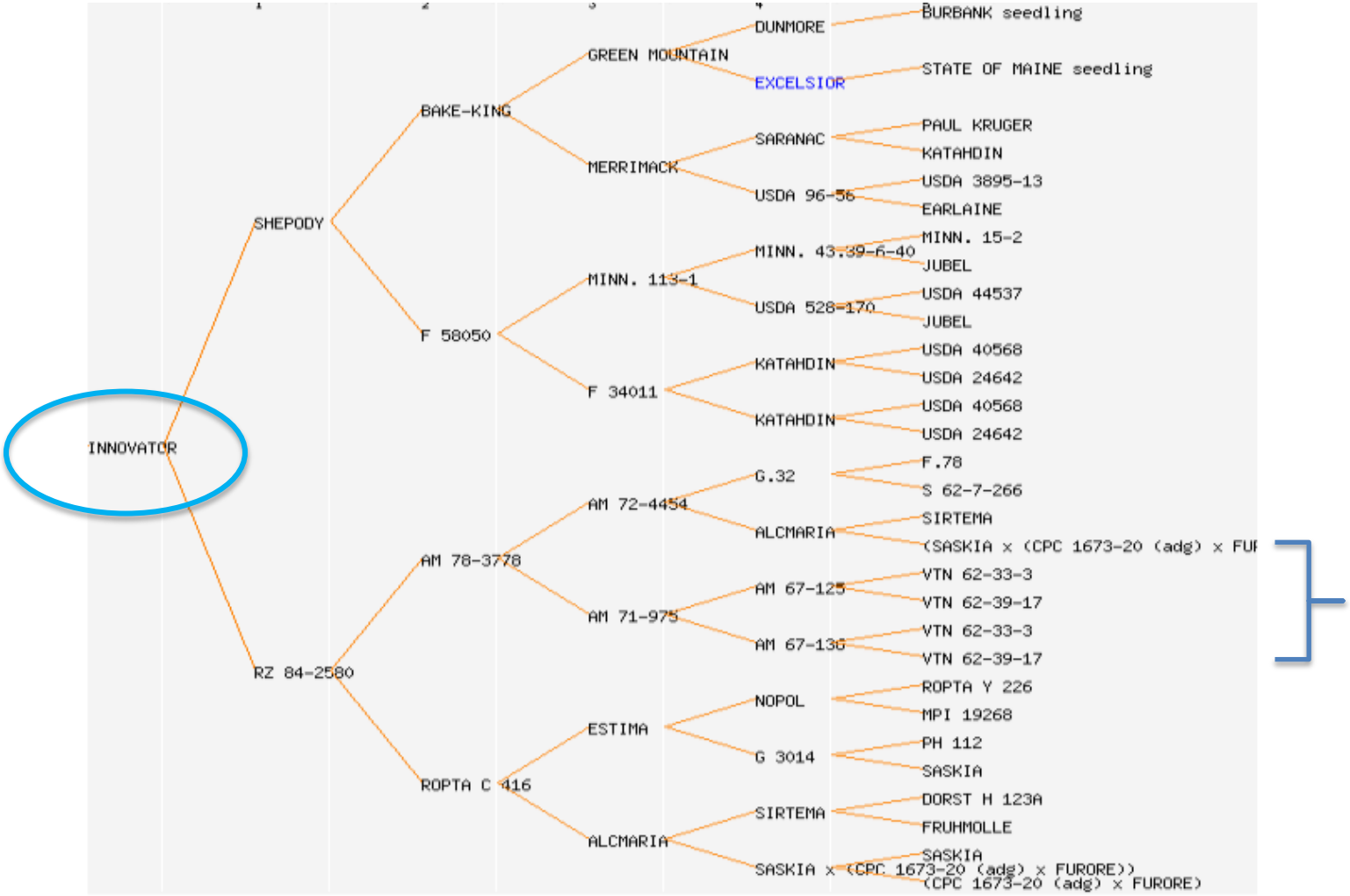


Preliminary results in more detail….



see Drummond Todd and Vanessa Young for more info

Pedigree for Innovator

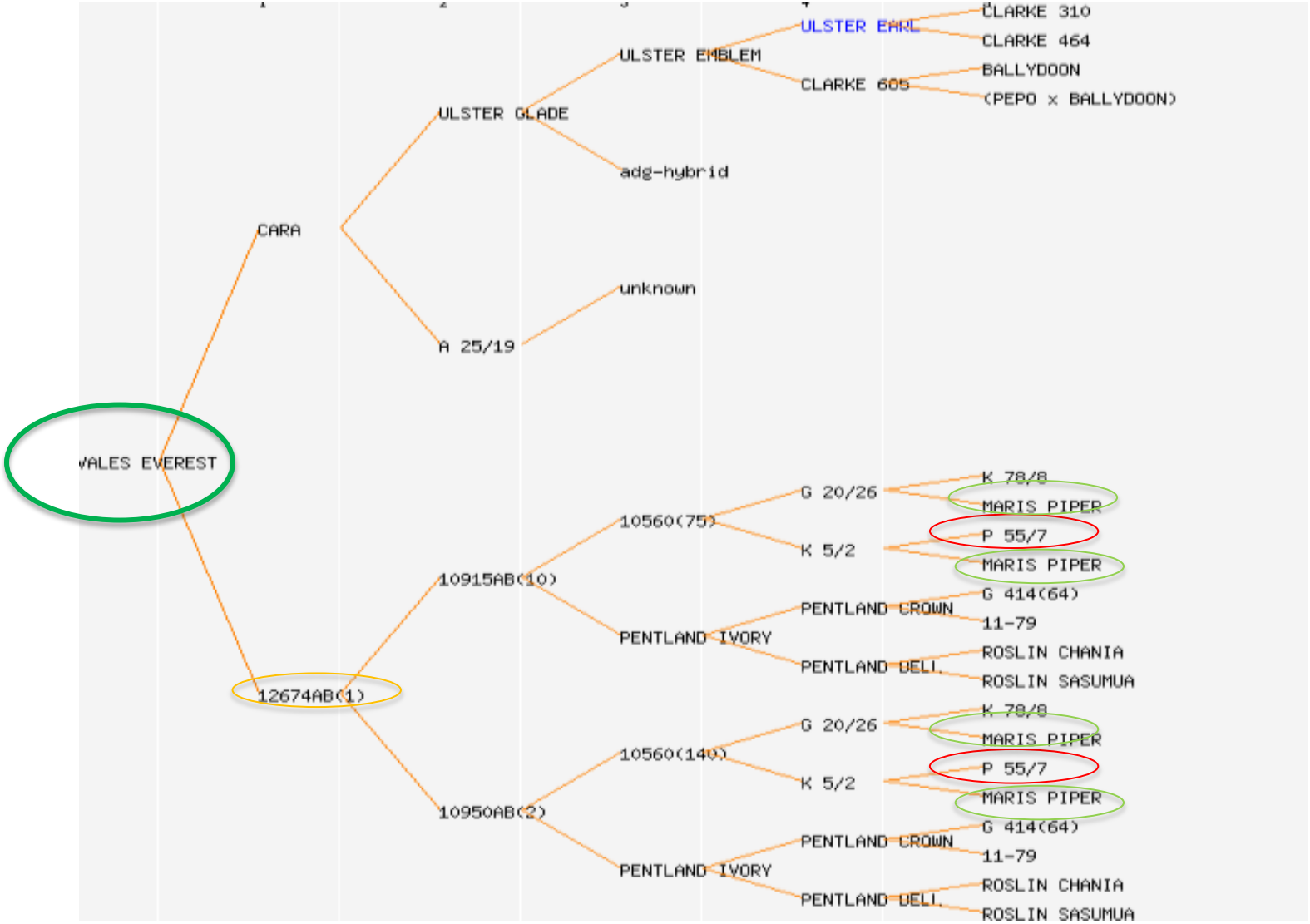


Resistance sources differ between breeding programmes

Gpa5 in Morag, Sante and VTN 62-33-3 from *S. vernei* accession V24/20

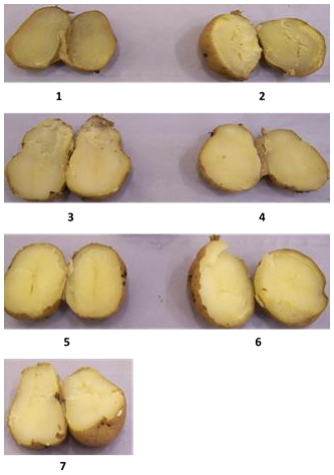
Gpa5 in Innovator from *S. vernei* accession LGU8

Pedigree for Vales Everest

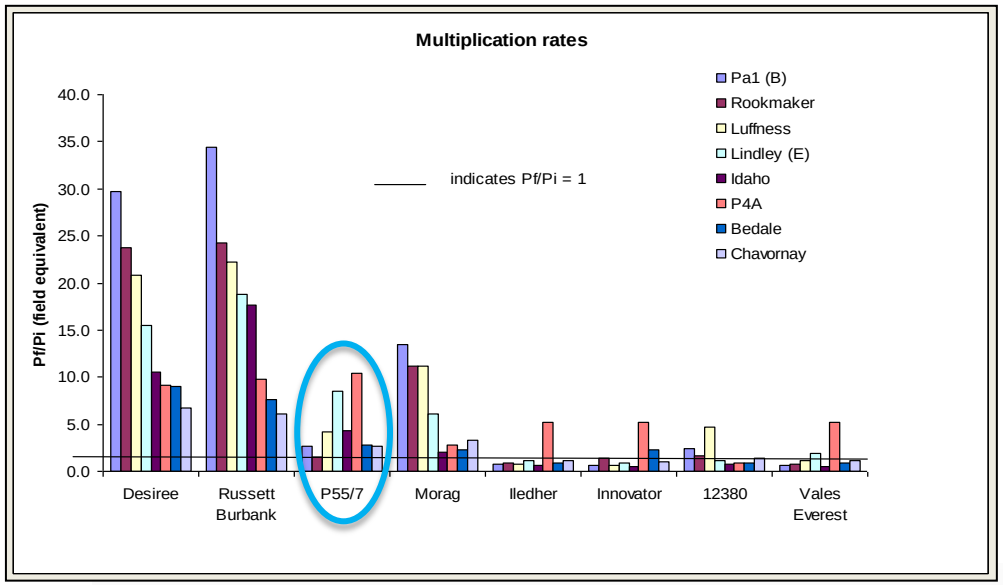


Other characters assessed in clones for *G. pallida* resistance

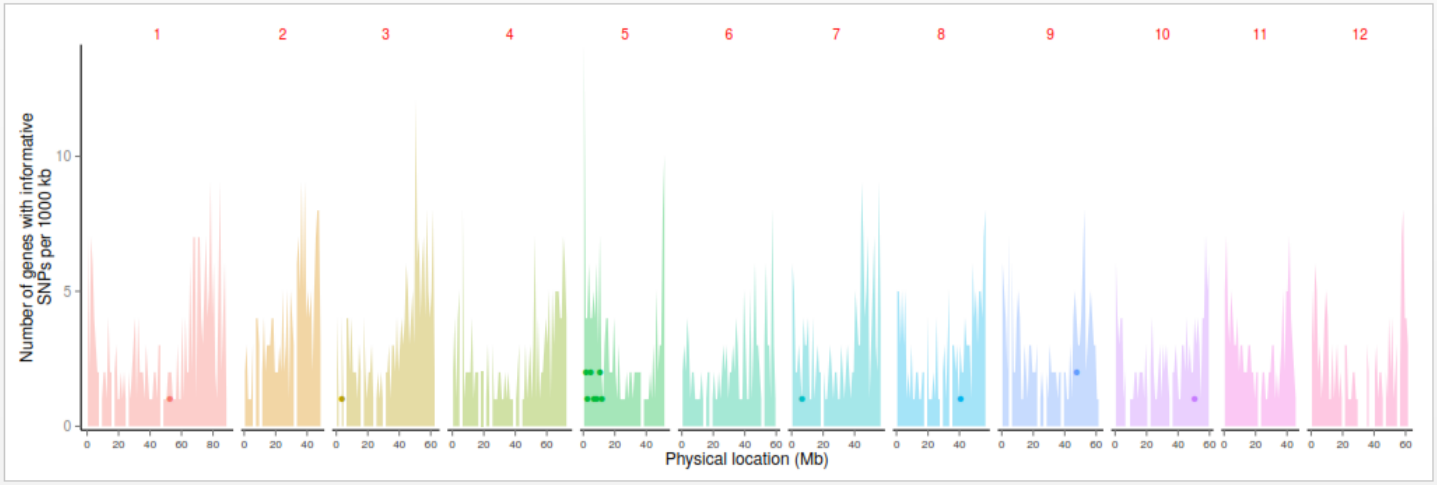
1) maturity – early, second early, main
2) shape – oval, long oval
3) skin – white, red eye
4) flesh white, white/cream, cream, medium lemon, lemon
5) internal condition
6) internal defect
7) dry matter
8) fry score
9) after cooking darkening
10) *G. rostochiensis* resistance (H1)
11) foliage blight resistance
12) tuber blight resistance



Other resistance to *G. pallida* in the pipeline: *Solanum multidissectum* H2



Shona Strachan
AHDB PhD student



Solanum spegazzinii resistance to *G. pallida*: large effect QTL on chromosome V

Ulrike Gartner
USDA funded PhD student

Kreike et al 1994 *Theor. Appl. Genet.,* Caromel et al 2003 *Theor. Appl. Genet.*

Ingo Hein
Glenn Bryan
Xinwei Chen

Drummond Todd
Vanessa Young
Ralph Wilson

Shona Strachan
Kyriakos Varypatakis
Dominik Laetsch
Brian Rigney
Ulrike Gartner

Sebastian Eves-van den Akker
John Jones

Alex Reid
John Pickup

Mark Blaxter

The James Hutton Institute
SASA Science and Advice for Scottish Agriculture
BBSRC bioscience for the future
GLOBAL Globodera Alliance
Perry Foundation
Felix Cobbold Trust
The University of Edinburgh
SSCR Scottish Society for Crop Research
AHDB Agriculture & Horticulture Development Board