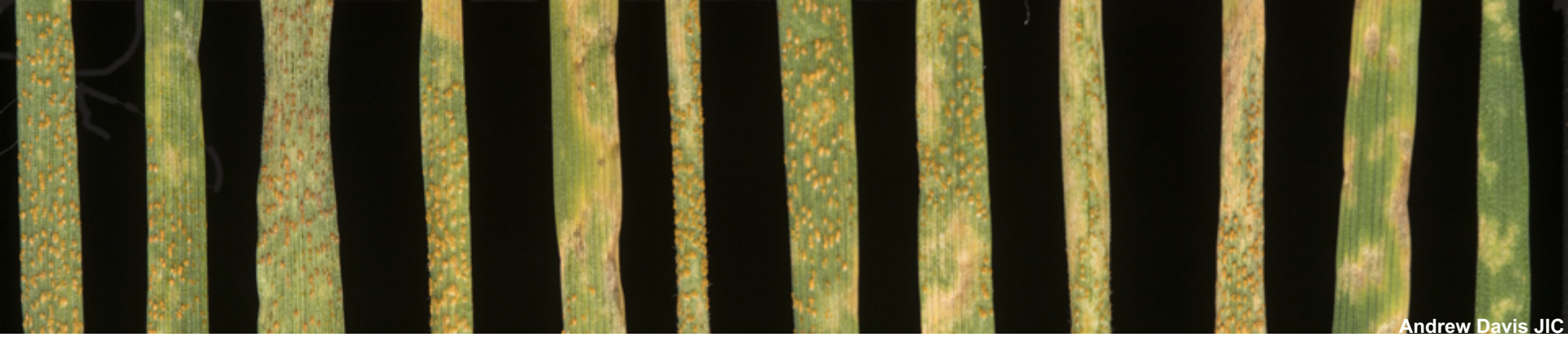


Hunting yellow rust resistance genes in bread wheat

Clémence Marchal

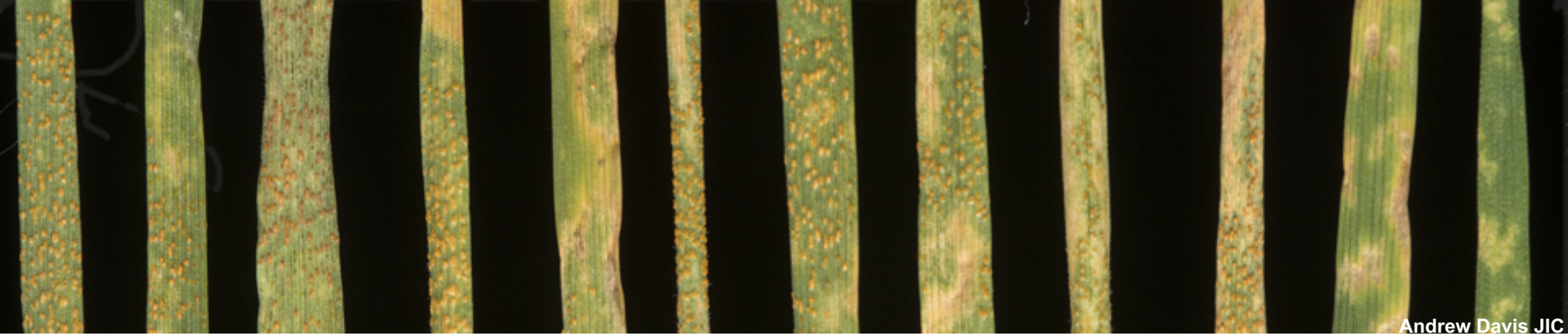
@ClemMarchal

John Innes Centre

Limagrain
from earth to life

UKCPVS

AHDB



Hunting yellow rust resistance genes in bread wheat

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CSIRO

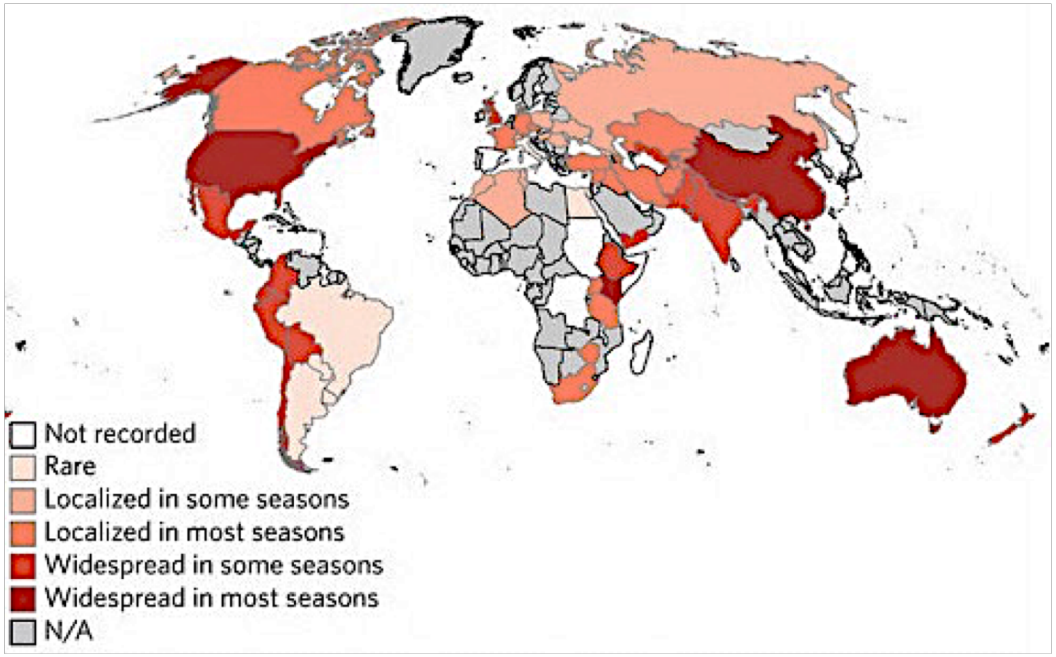
THE UNIVERSITY OF SYDNEY

NIAB

Cereal rusts are among the major biotic constraints in world wheat production

- Three main wheat rust diseases caused by *Puccinia graminis* f. sp *tritici*, *Puccinia triticina*, *Puccinia striiformis* f. sp. *tritici*

Stem rust | Leaf rust | Stripe rust



Stripe rust global incidence 2000-2012
Adapted from Beddow et al., 2015, data from Wellings, 2011

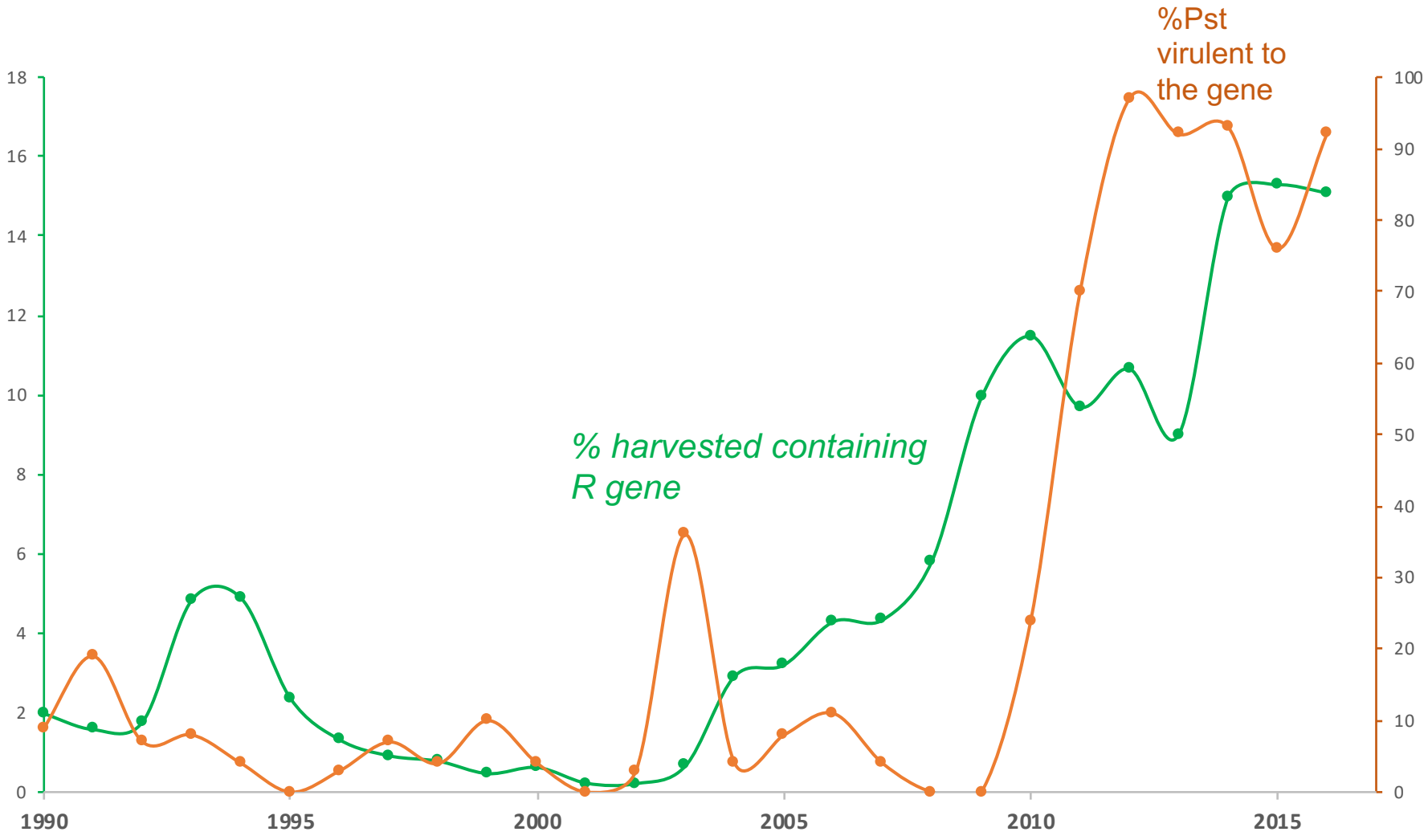
Cereal rusts are among the major biotic constraints in world wheat production

- Equivalent of 1/3 of the total UK wheat harvest lost to yellow rust world-wide
  - Monetary losses due to yield – but not only:

- Controlling rust is costly

- Cost of breeding for resistance, delays genetic gain

Deploying single resistance is not durable



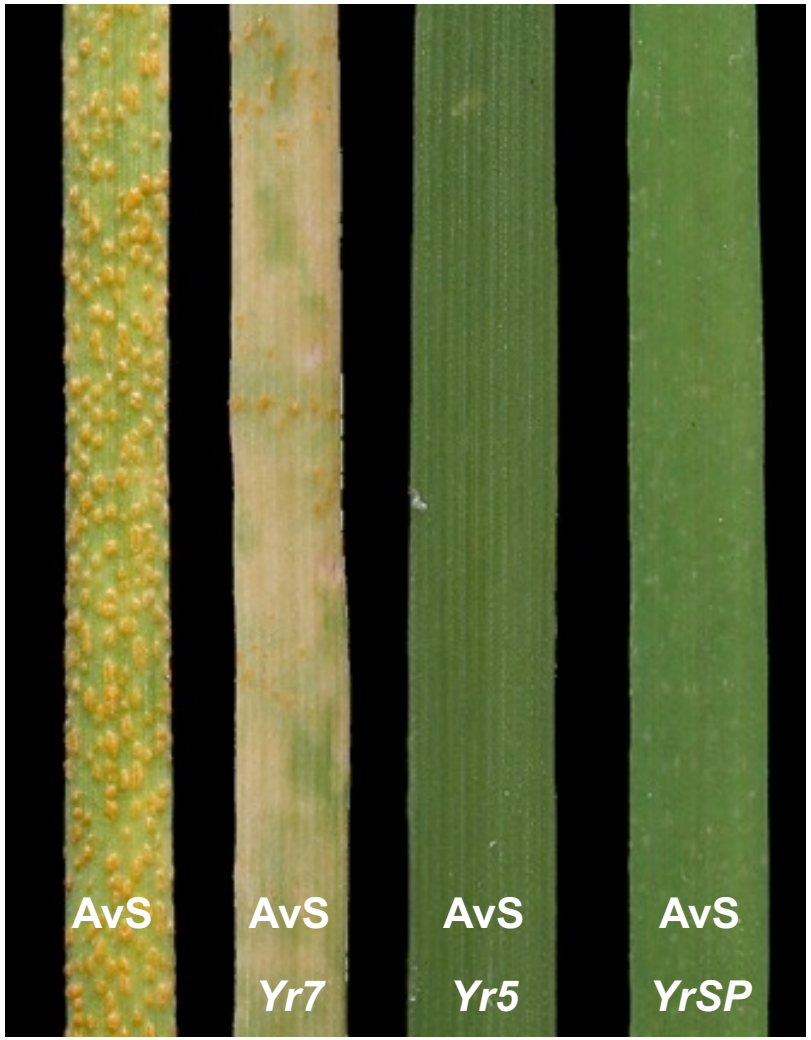
From UKCPVS and SeedStats (NIAB-TAG)

Cereal rusts are among the major biotic constraints in world wheat production

- Equivalent of 1\3 of the total UK wheat harvest lost to yellow rust world-wide
  - Money losses due to yield – but not only:
- Controlling rust is costly
- Cost of breeding for resistance, delays genetic gain

How to address this and ensure genetic resistance durability?

Yr7, *Yr5* and *YrSP*: Single dominant; Seedling resistance

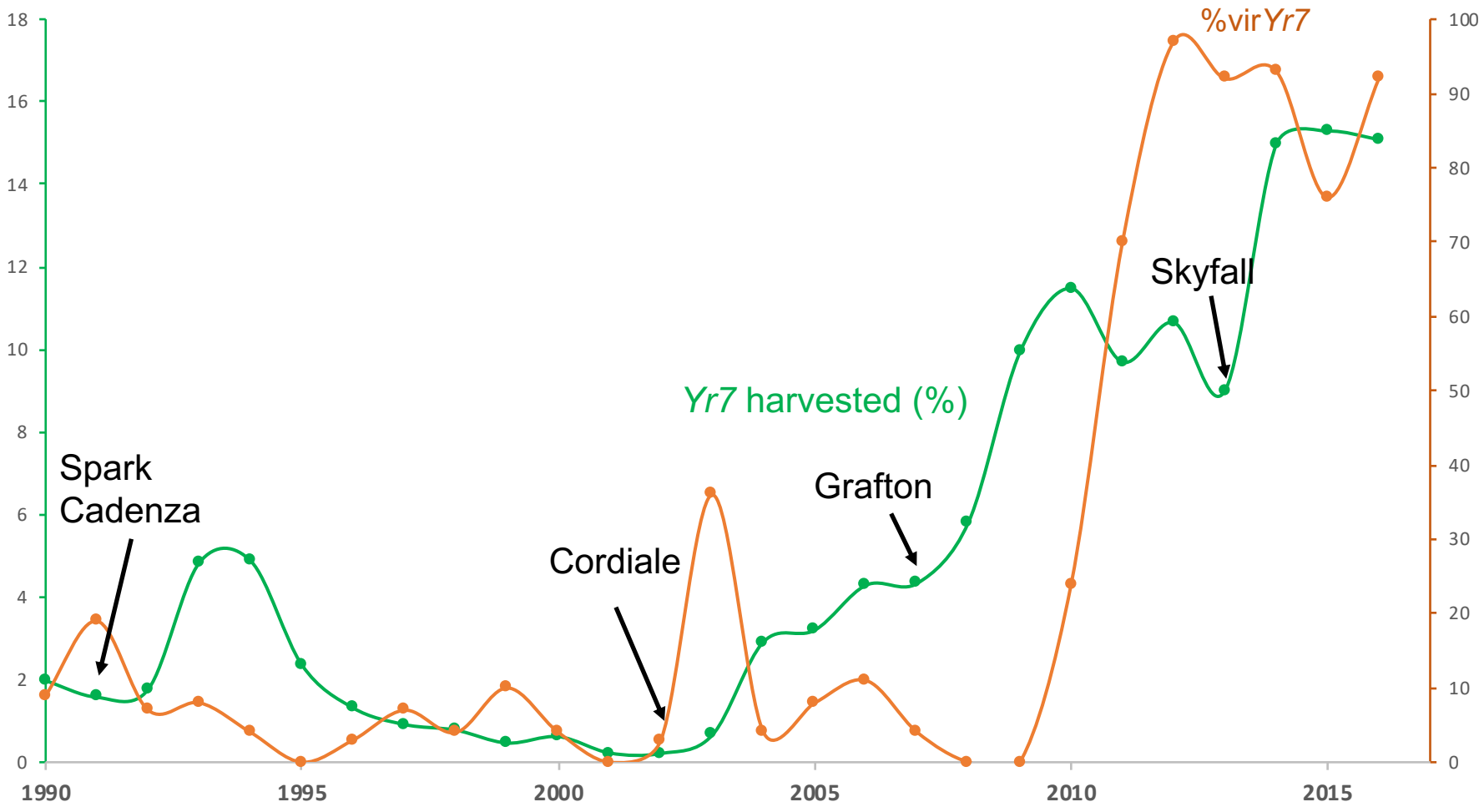


Iumillo
Thatcher
Cadenza

Album
(spelt)

Spaldings
Prolific

Yr7, *Yr5* and *YrSP* have different specificities



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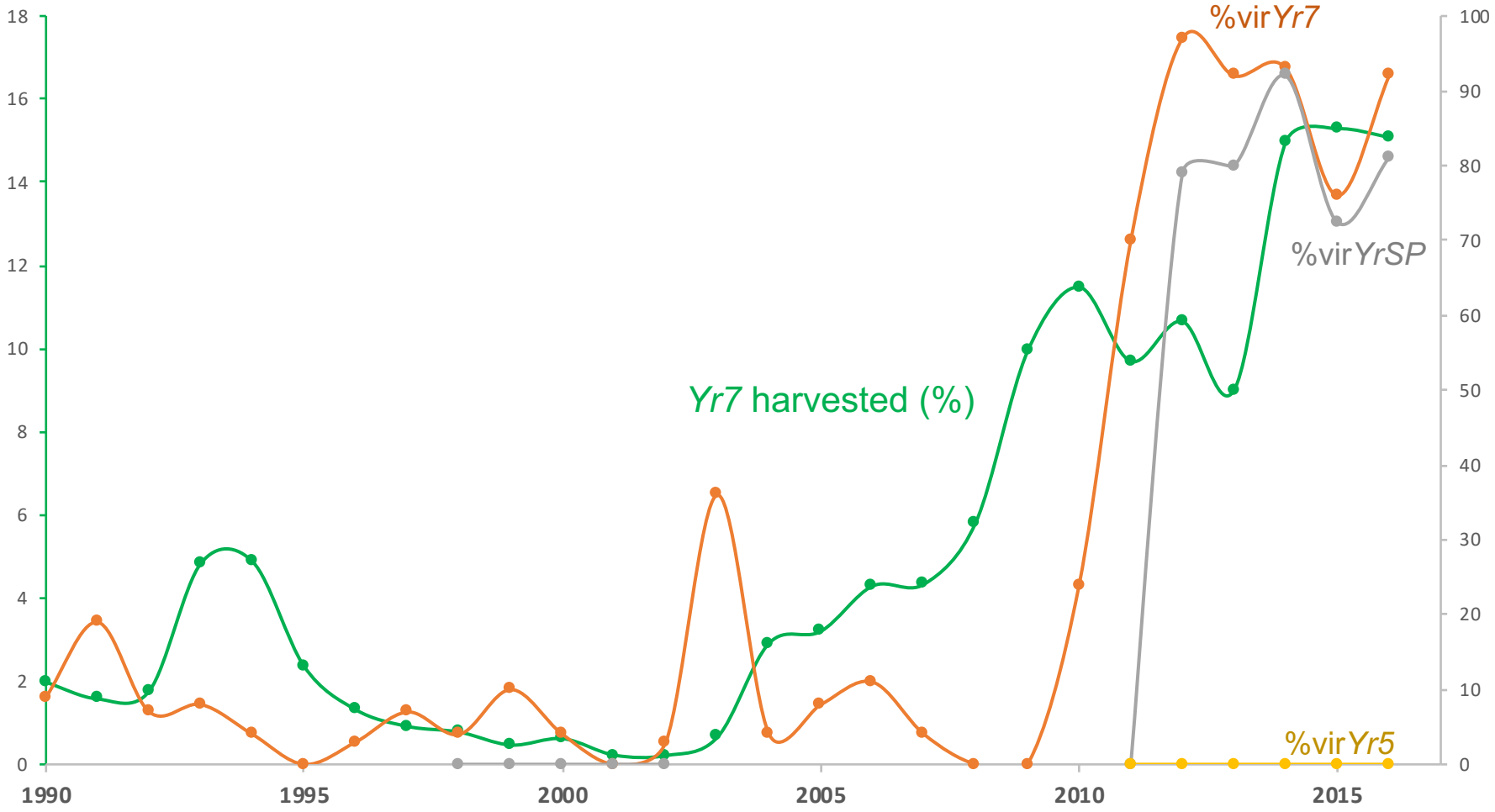
Yr7, *Yr5* and *YrSP* have different specificities



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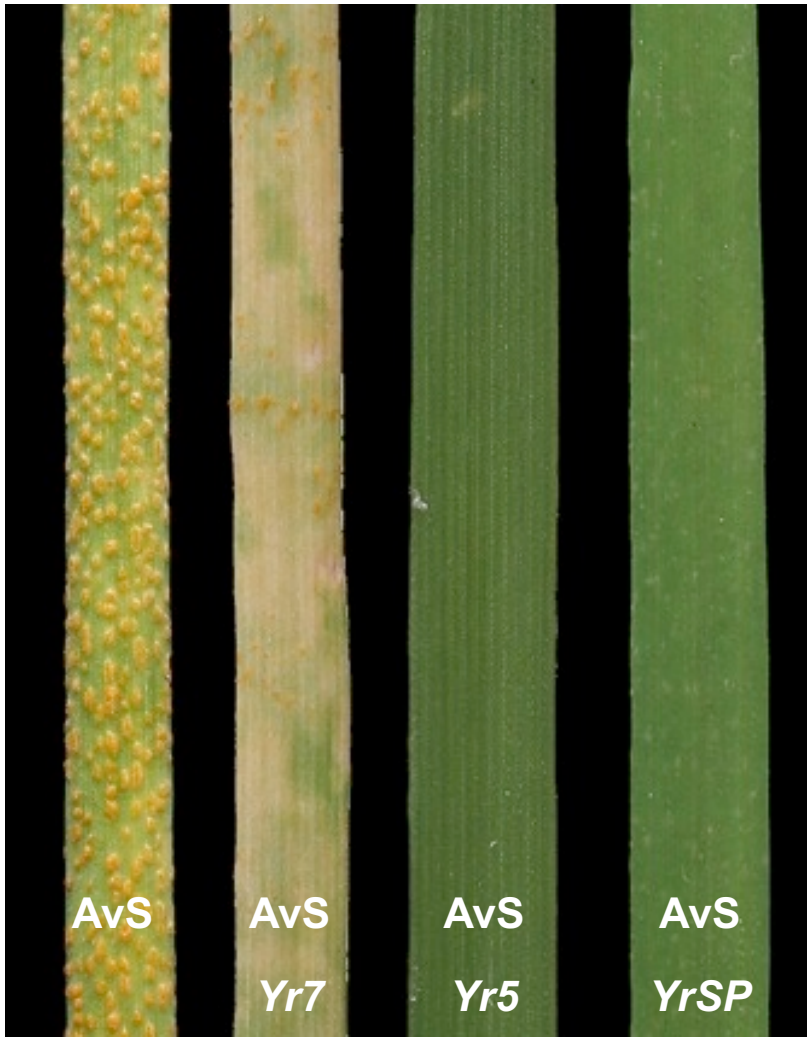
Yr7, *Yr5* and *YrSP*: Single dominant; Seedling resistance



NB-ARC containing **L**eucine-**R**ich-Repeats protein**s**

NLRs

Highly conserved structure

Specific to this gene family

Are *Yr7*, *Yr5* and *YrSP* allelic?

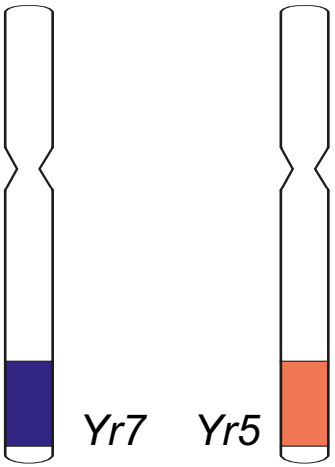
allelism?
closely linked?

Johnson et al. (1984)
Zhang et al. (2009)

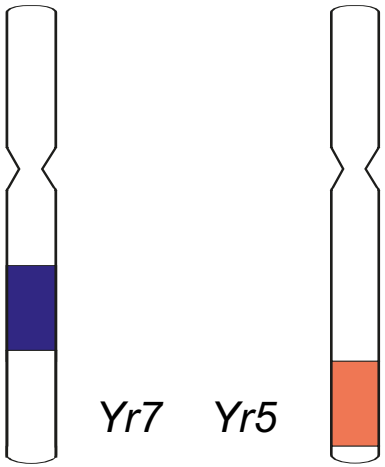
closely linked

Feng et al. (2015)

Yr7 = *Yr5* ⟷ *YrSP*



Two version of the same gene?

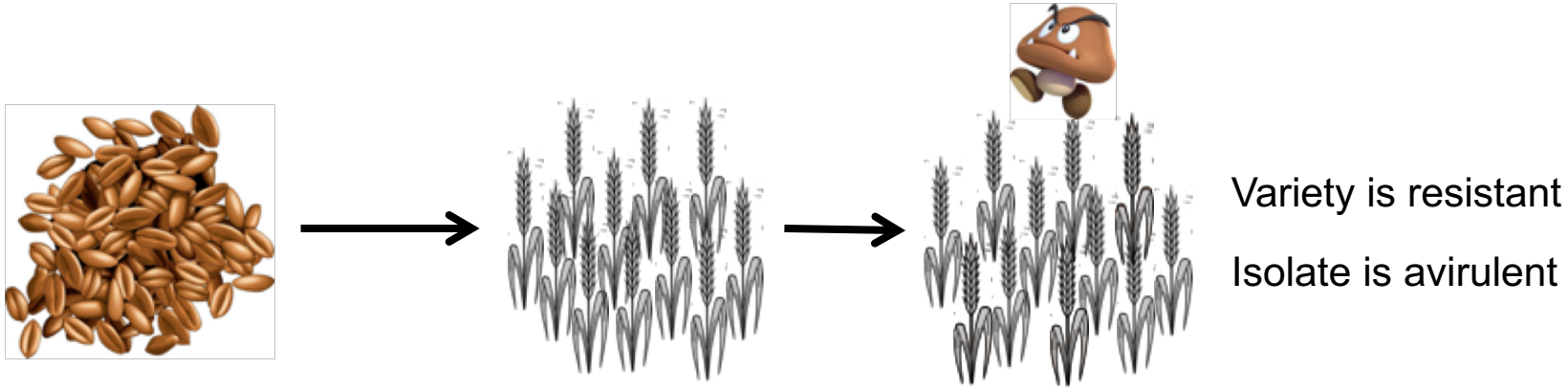


Two different genes?

Hypothesis

Yr7, *Yr5* and *YrSP* encode three distinct NLR proteins conferring different resistance specificities to *Puccinia striiformis* f. sp. *tritici* (PST)

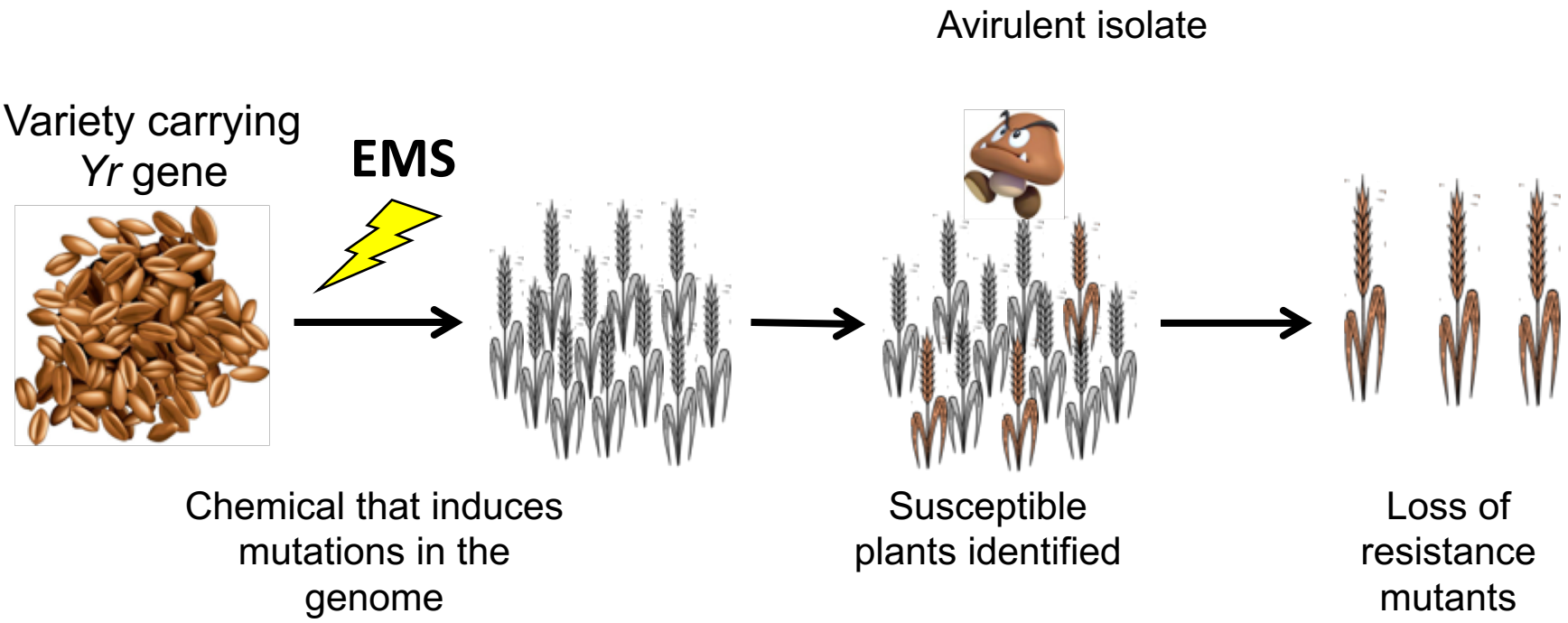
Mutational genomics



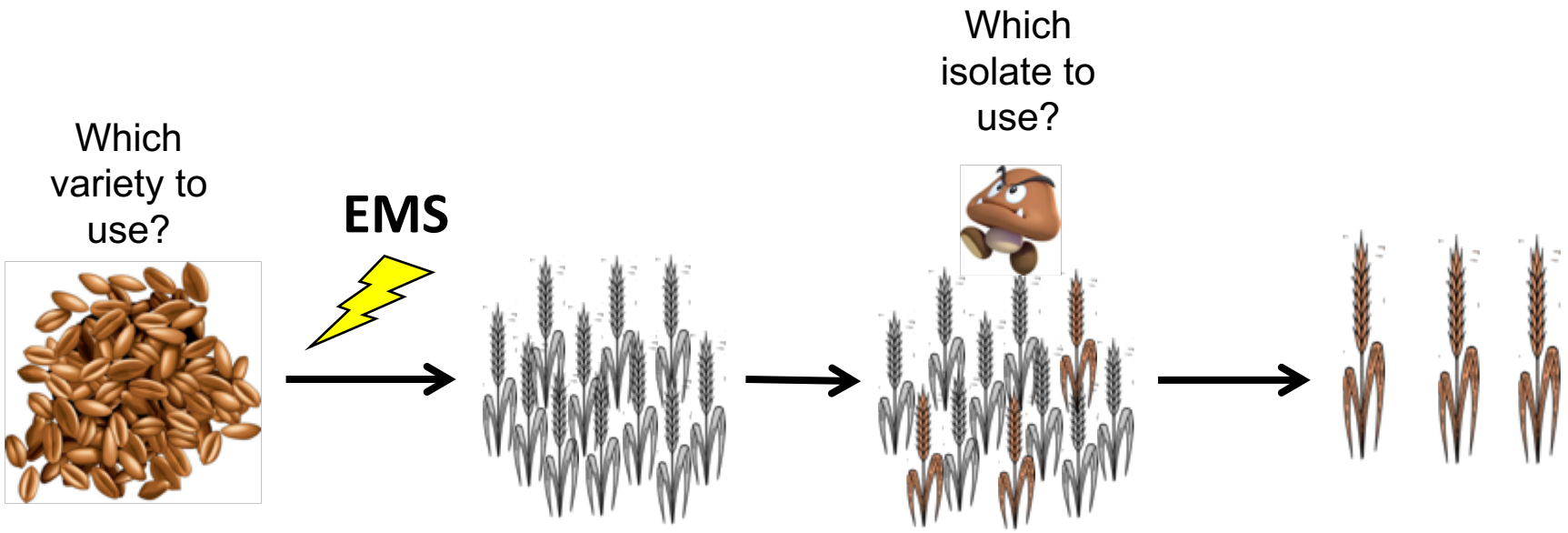
Variety is resistant

Isolate is avirulent

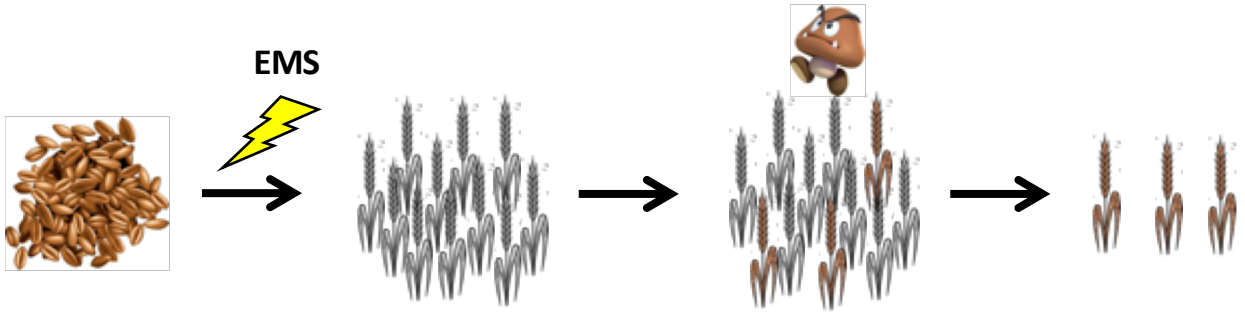
Mutational genomics



Mutational genomics

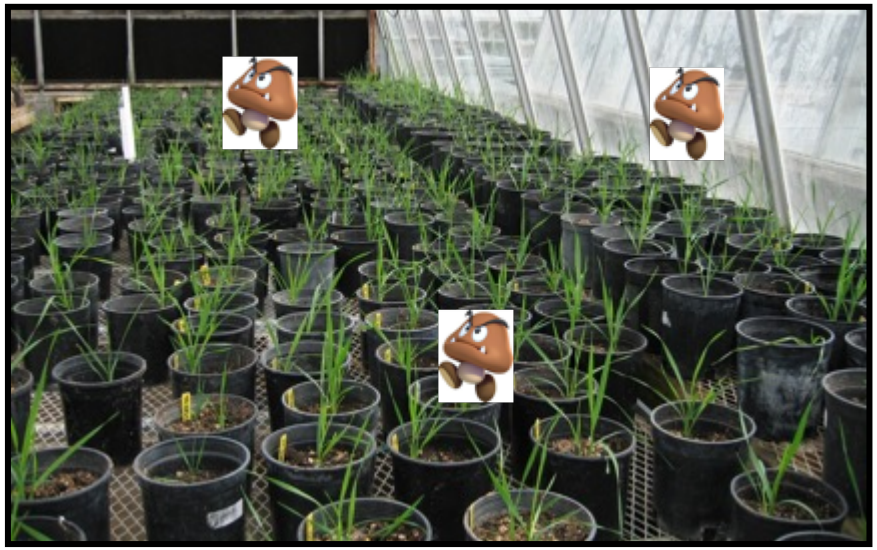


Mutational genomics



Target	Plant material
Yr7	Cadenza EMS mutants (Krasileva *et al.*, 2017)

PST 08/21 from NIAB

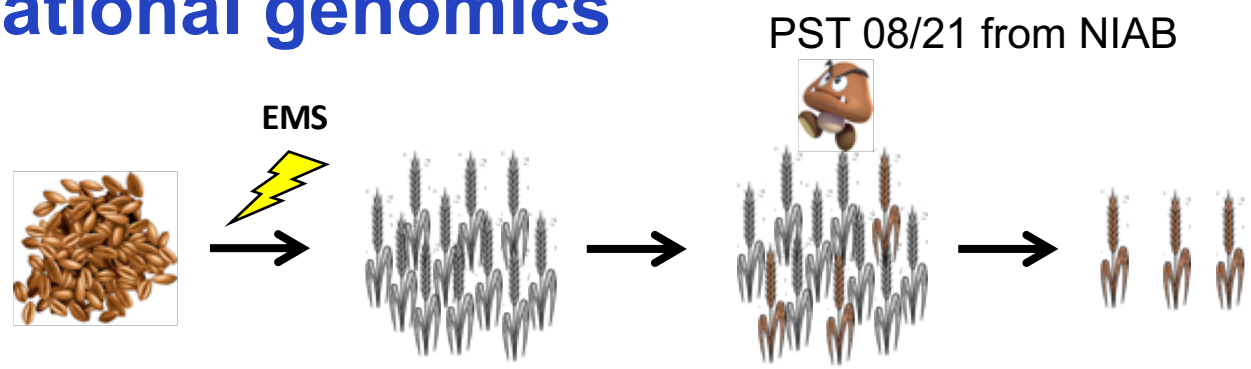


1,000 lines screened

Paul Fenwick

Limagrain
from earth to life

Mutational genomics



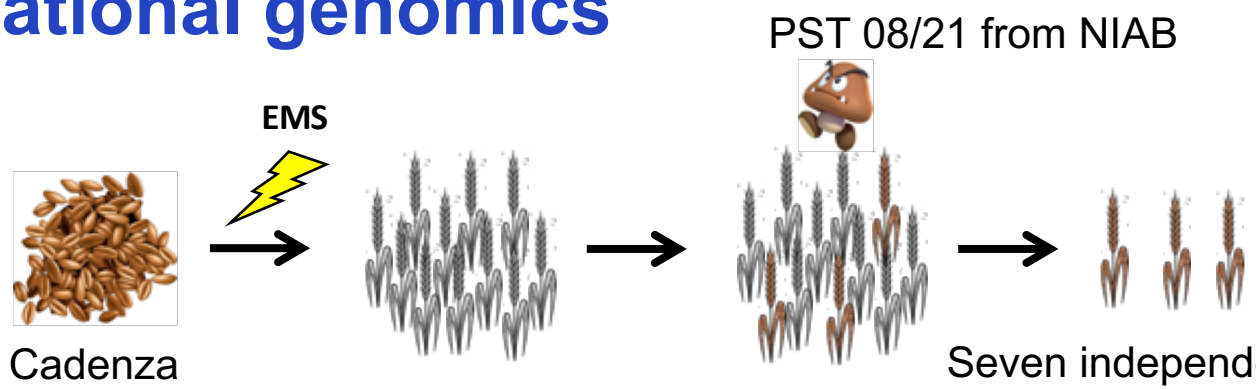
Target	Plant material
Yr7	Cadenza EMS mutants (Krasileva *et al.*, 2017)

Phenotype screening of the M_4 plants with an avirulent yellow rust isolate

Cadenza wt
Typical *Yr7* response

Mutant line
Susceptible response

Mutational genomics

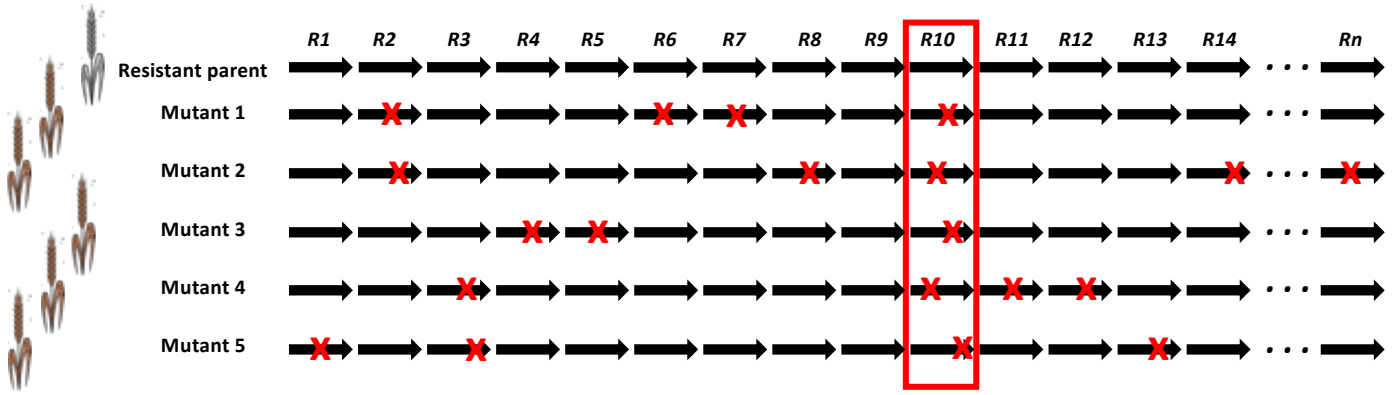


NLR capture, enrichment and sequencing (RenSeq)

Jupe et al., 2013

Highly conserved structure

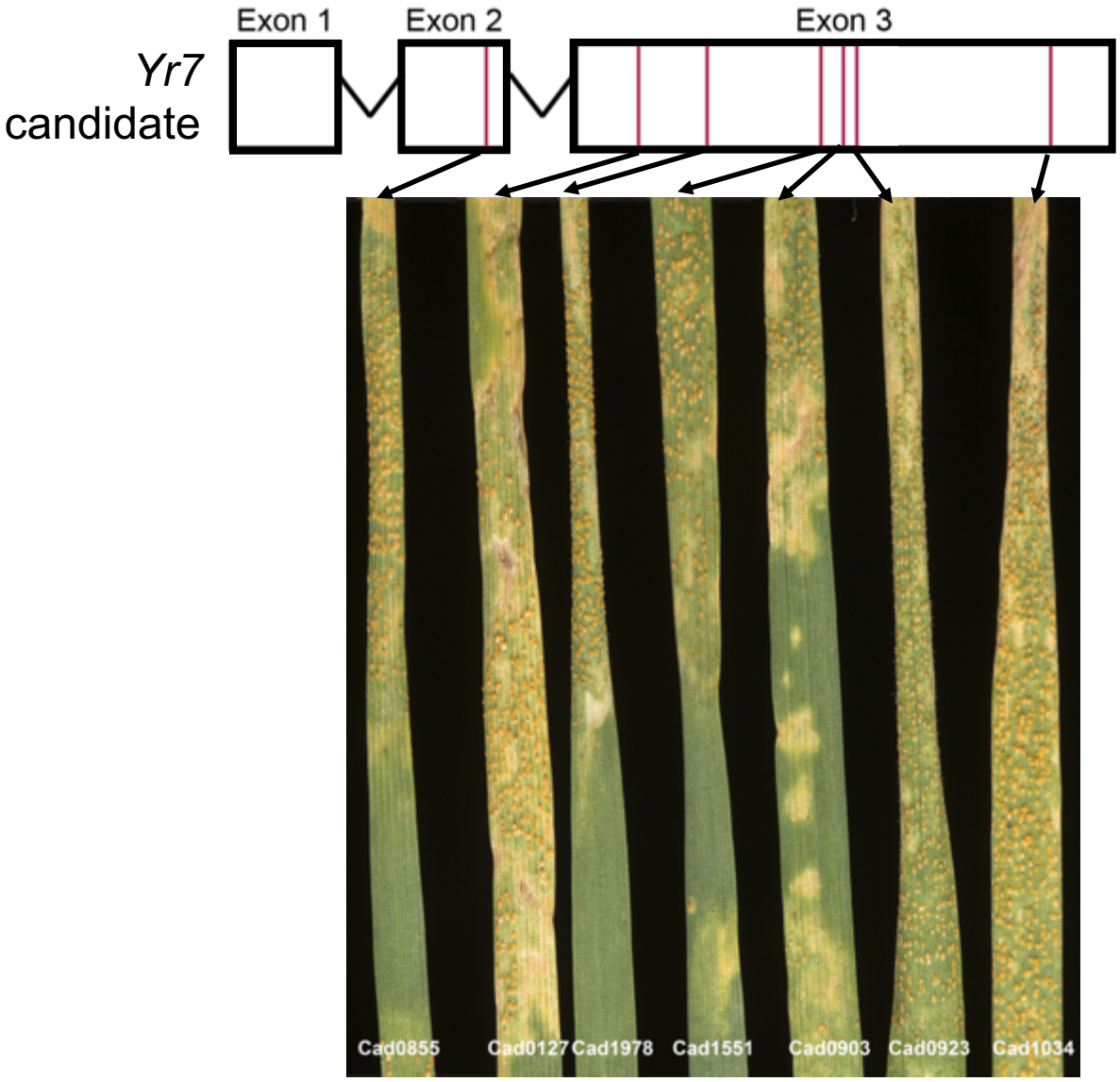
Specific to this gene family



MutantHunter

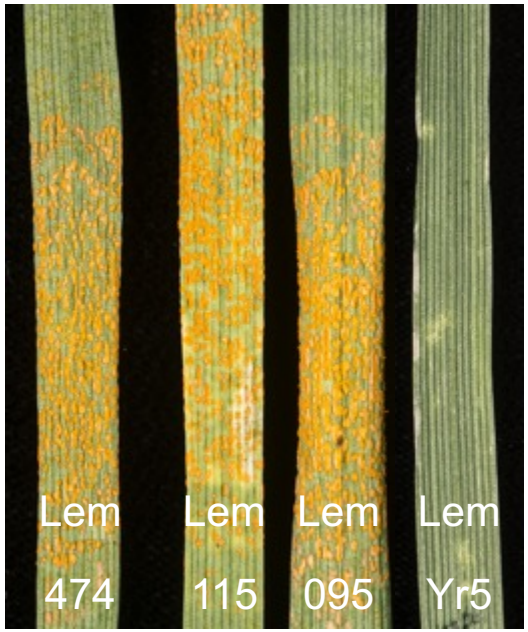
Steuernagel et al., 2016

Single candidate for *Yr7*



Strategy

Target	Plant material	Approach
Yr7	Cadenza TILLING mutants (Krasileva *et al*., 2017)	MutRenSeq on 7 mutants
Yr5	Mutants from McGrann *et al. (*2014)	MutRenSeq on 7 mutants

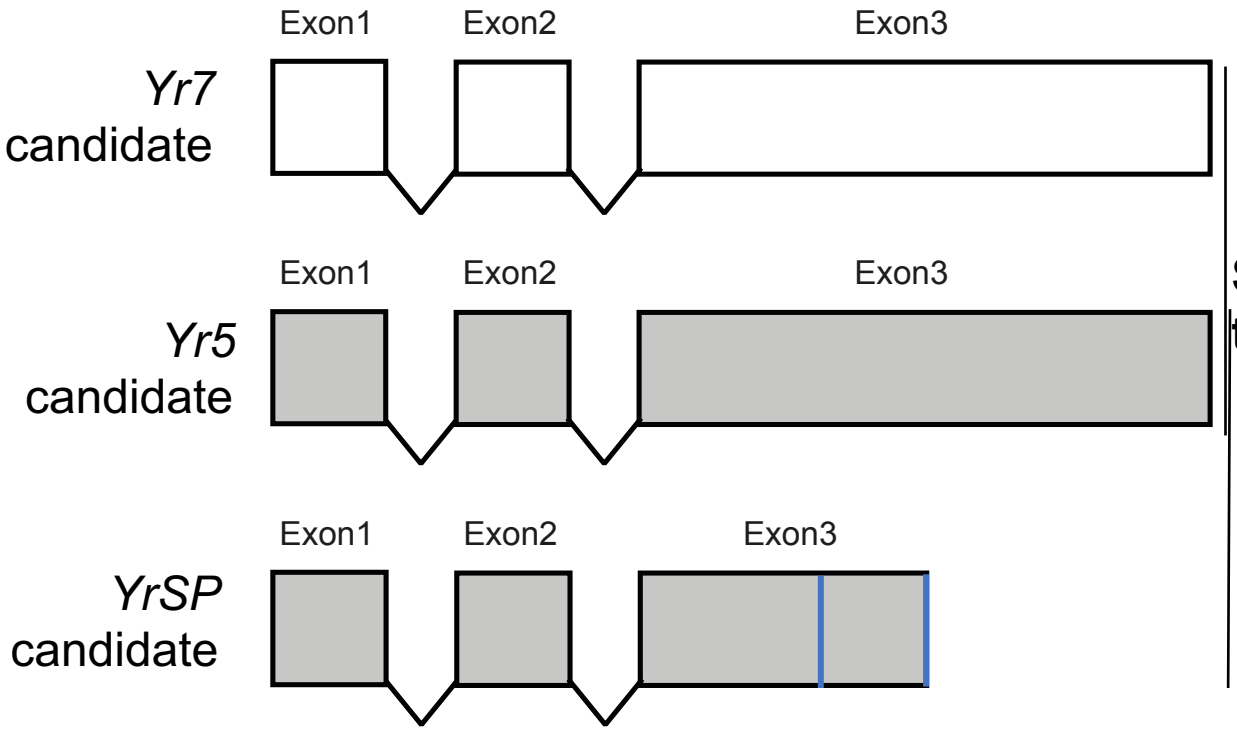


From Lesley Boyd

Strategy

Target	Plant material	Approach
Yr7	Cadenza TILLING mutants (Krasileva *et al*., 2017)	MutRenSeq on 7 mutants
Yr5	Mutants from McGrann *et al. (*2014)	MutRenSeq on 7 mutants
YrSP	Mutants in AvocetS+*YSP* isogenic lines	MutRenSeq on 4 mutants (*YrSP)*
	Peng Zhang Robert McIntosh	Jianping Zhang

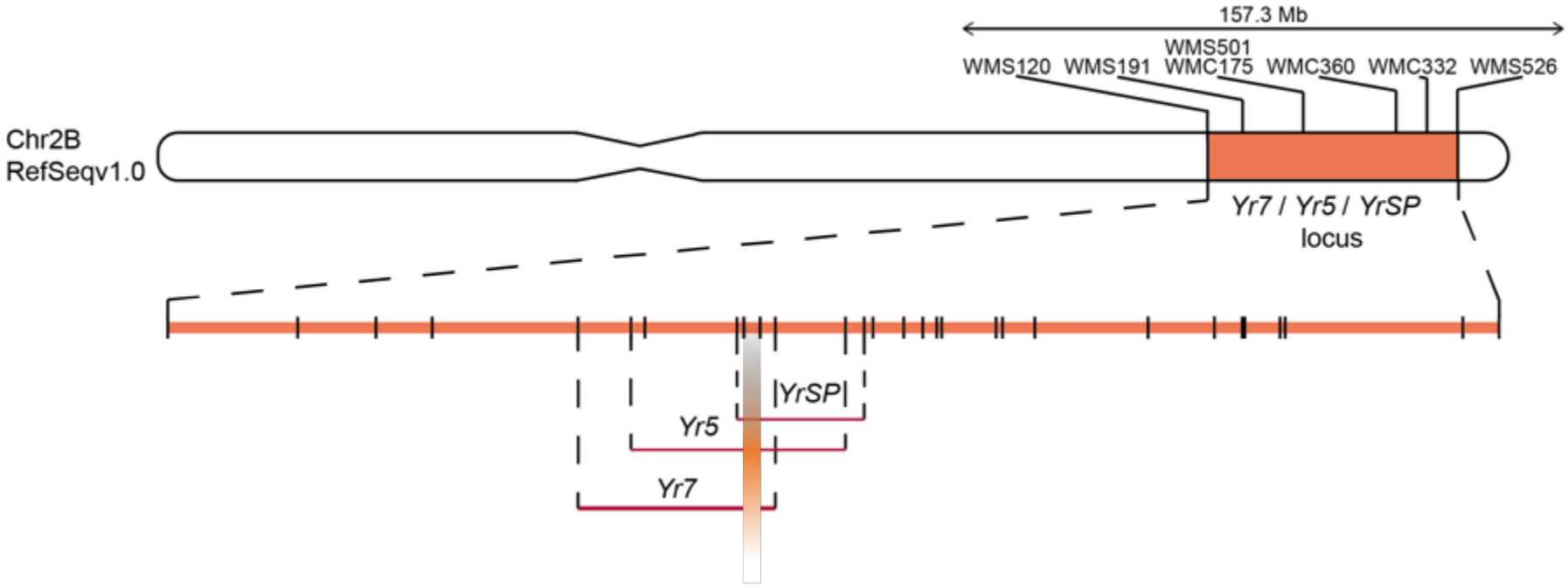
Yr7 and *Yr5* candidates are different



Similar but not the same gene!

Alleles?

Yr7, *Yr5* and *YrSP* candidates map to the *Yr7*/*Yr5*/*YrSP* genetic interval



Take home

1) MutRenSeq + Genetic linkage = Candidate confirmation

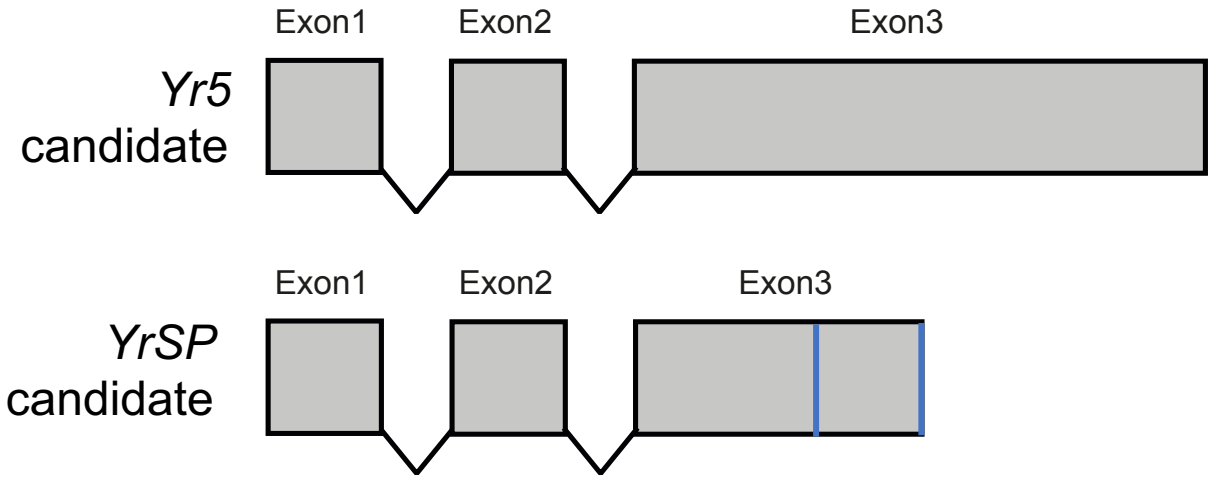
2)

closely linked different genes

Alleles

$$Yr7 \neq Yr5 = YrSP$$

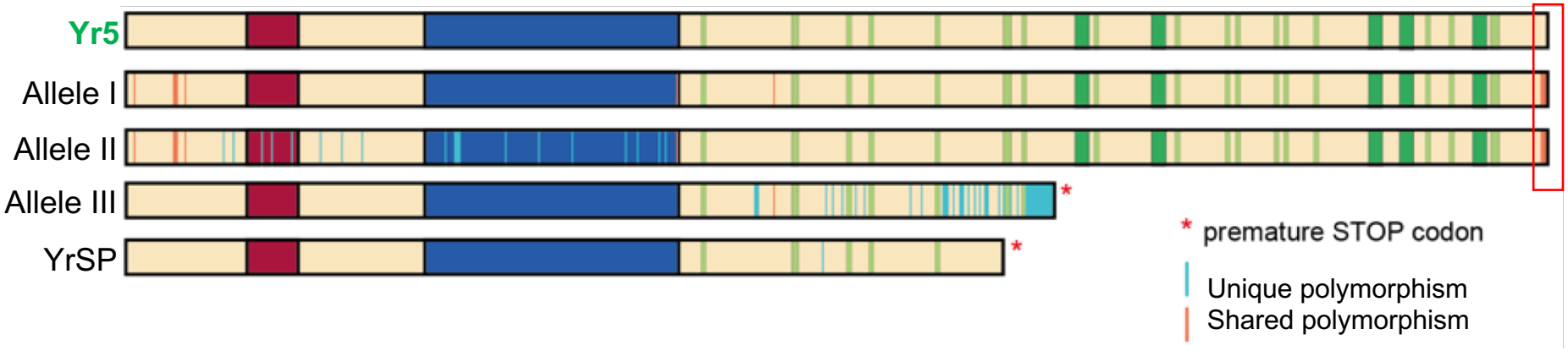
3)



Almost identical – yet have different resistance spectra!

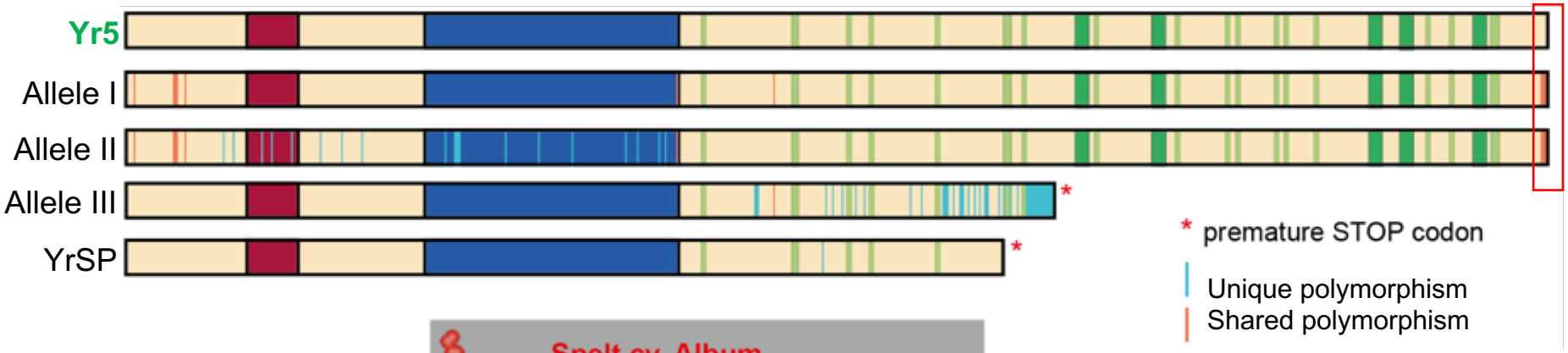
Why is this new information of use for the breeding community?

Yr5 is conserved in sequenced bread and durum wheat cultivars



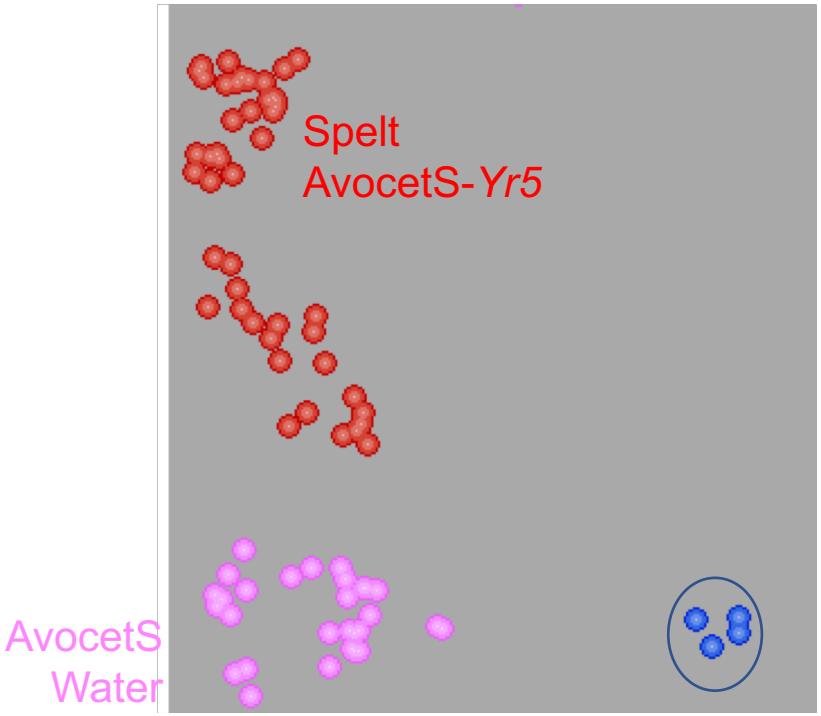
We have to make sure to select the right *Yr5* allele

Gene-specific marker for *Yr5*



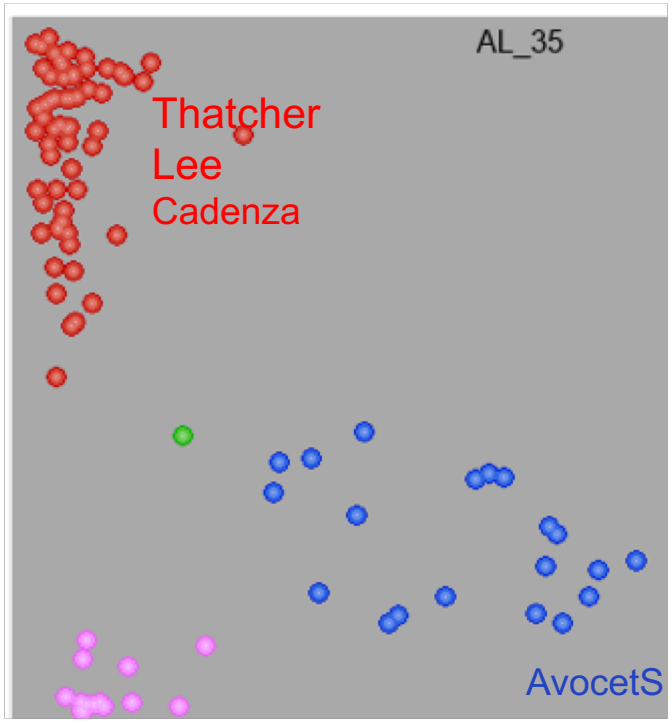
Not found in UK RL varieties

Gene-specific marker for *YrSP*



Not found UK RL varieties

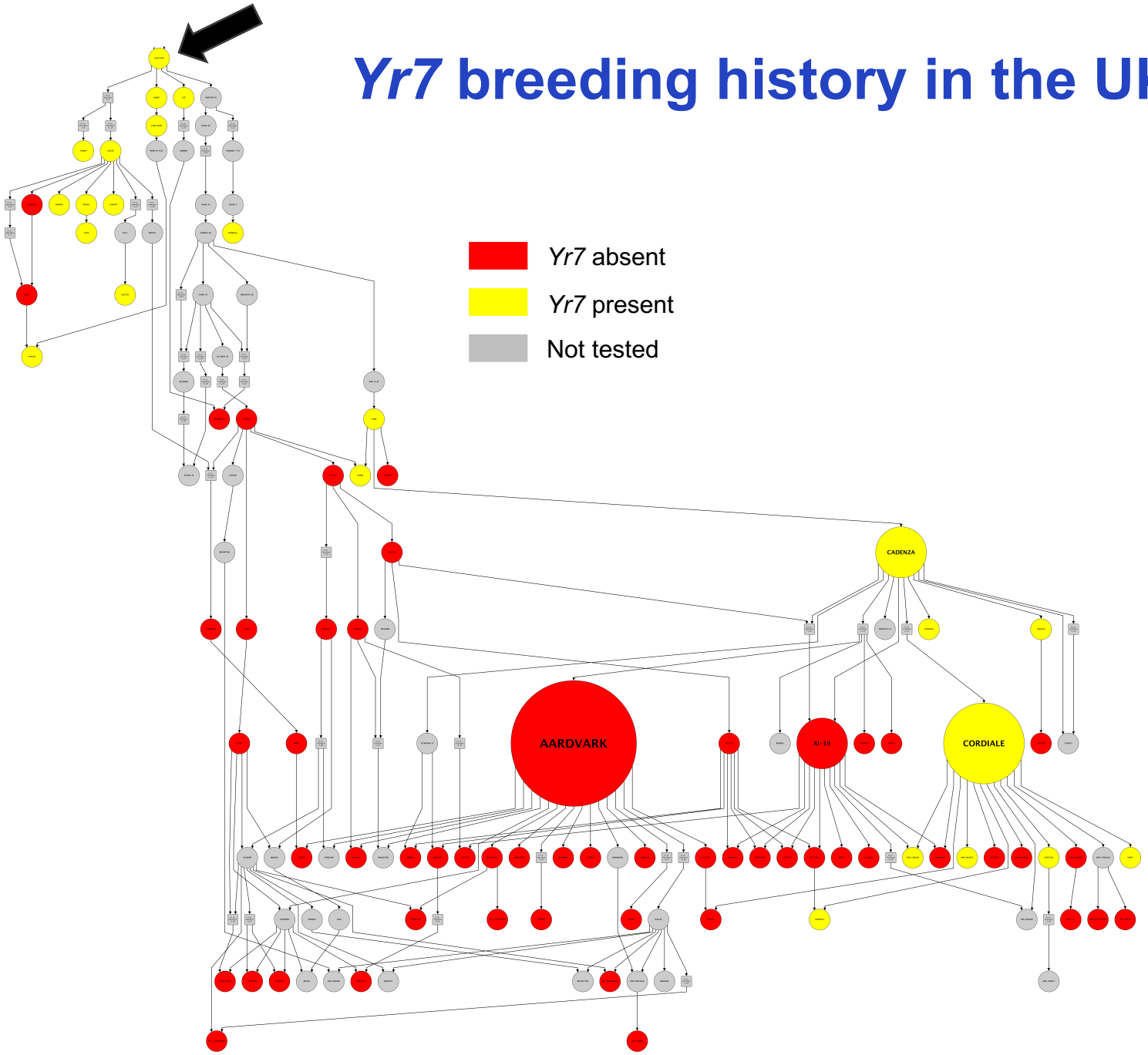
Gene-specific marker for *Yr7*



Tested on a set of Cadenza-derivatives + known *Yr7* carriers

Found in 4.4 % of UK RL varieties (including Cordiale, Skyfall)

Yr7 breeding history in the UK



Take home

1) We cloned *Yr7*, *Yr5* and *YrSP* (MutRenSeq + Genetics)

2) closely linked different genes

Alleles?

$$Yr7 \neq Yr5 = YrSP$$

+ Novel alleles?

3) Diagnostic markers available:

Free to read here

Acknowledgments

Uauy group
Nikolai Adamski
Wulff group
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Richard Goram

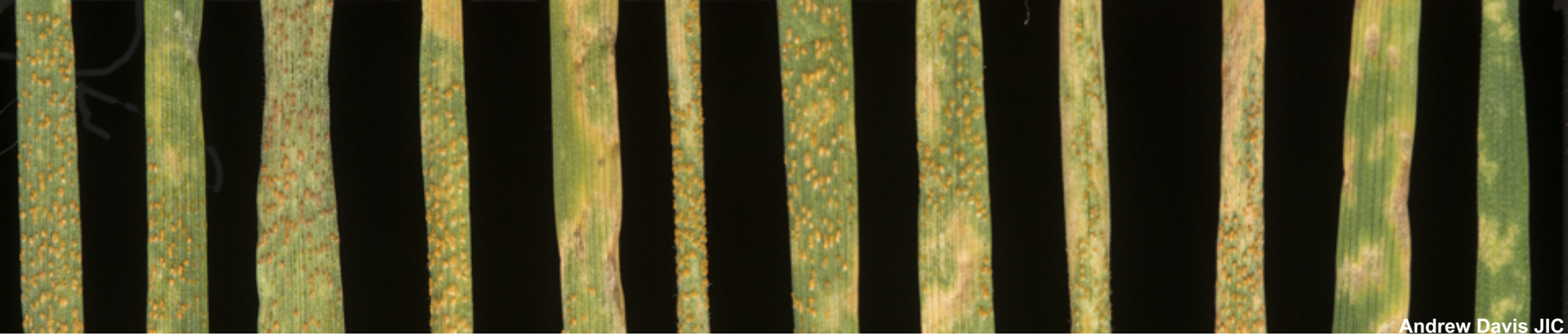
Simon Berry
Paul Fenwick
Seb Specel

Evans Lagudah
Jianping Zhang

Peng Zhang
Robert McIntosh

Lesley Boyd

JIC Horticultural services and Limagrain Rothwell staff



Thank you for your attention