Potato Pathology R & D in HZAU

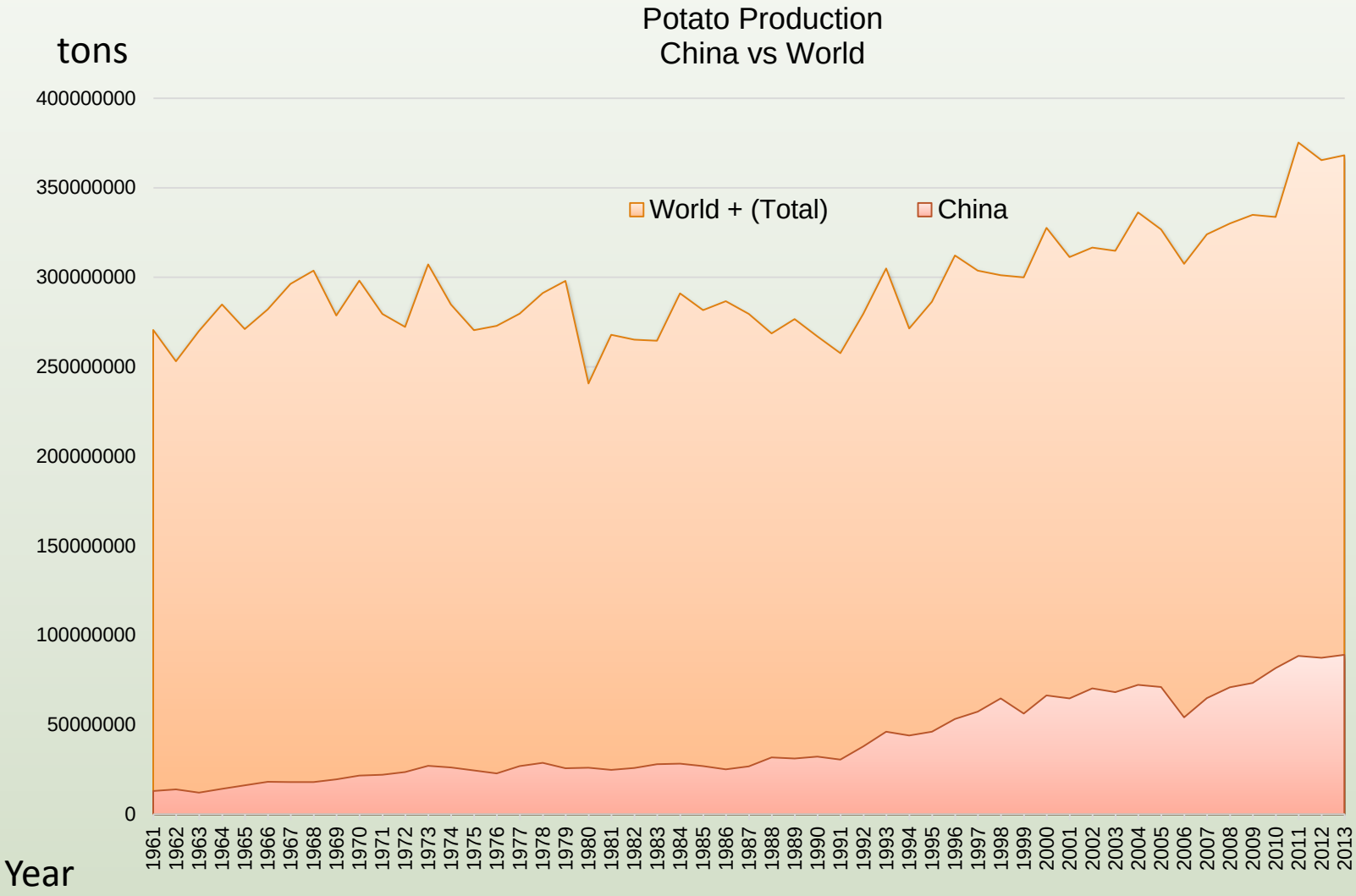
XIE CONGHUA, TIAN ZHENDONG, DU JUAN & JIANG RUI

HUAZHONG AGRICULTURAL UNIVERSITY

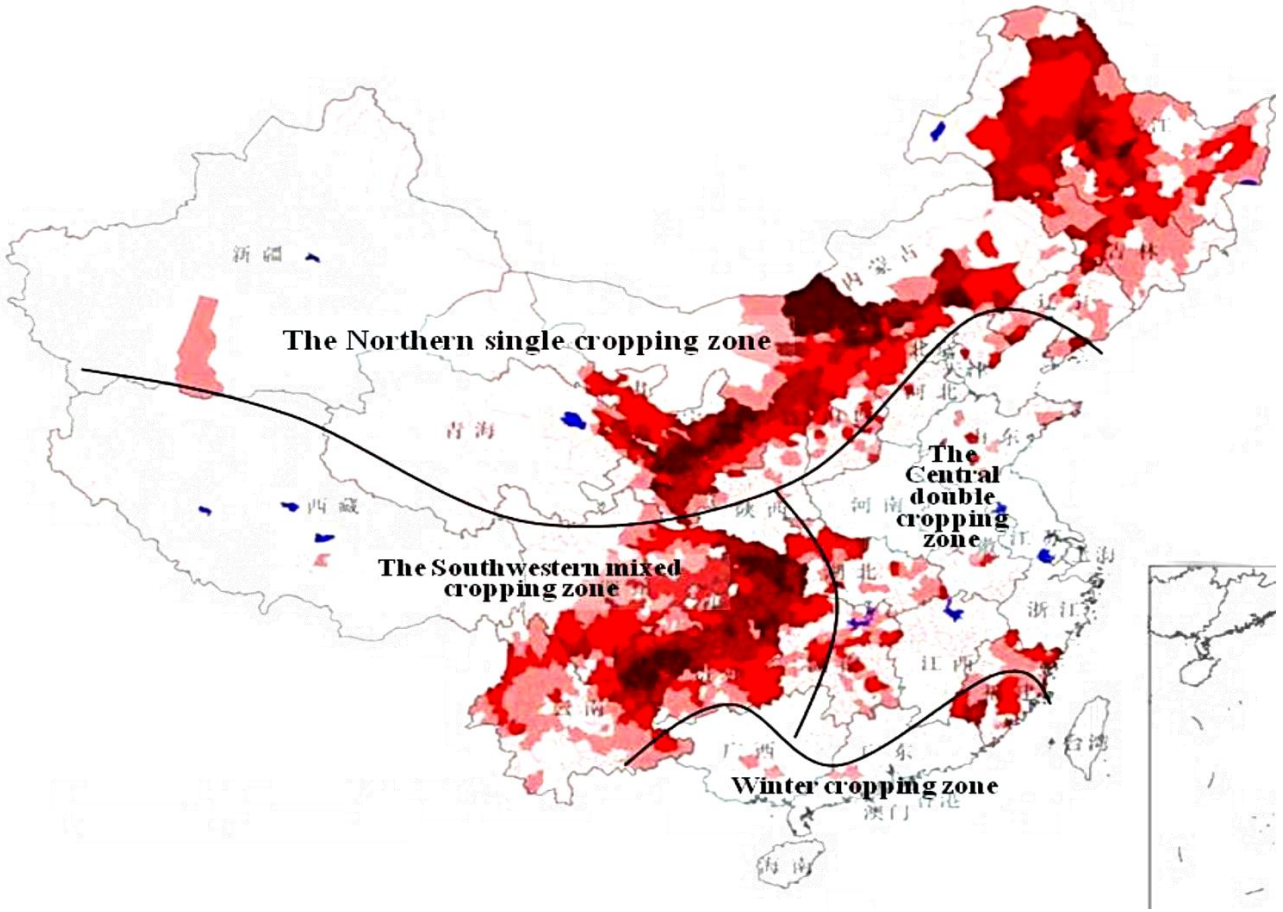
2016.8 EAPR, DUNDEE

Where we are

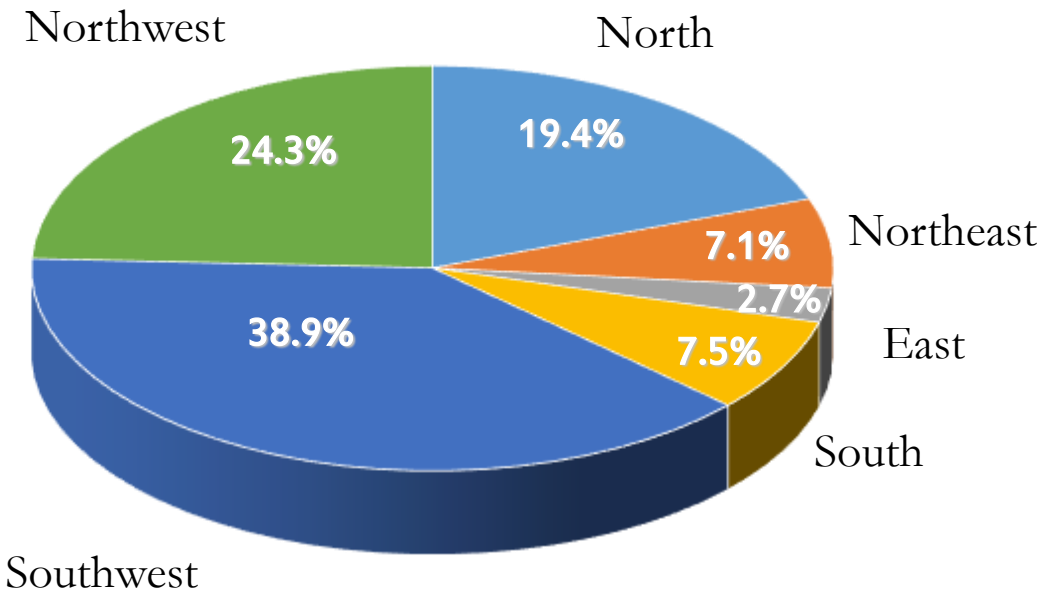
Potato Production



Potato Distribution

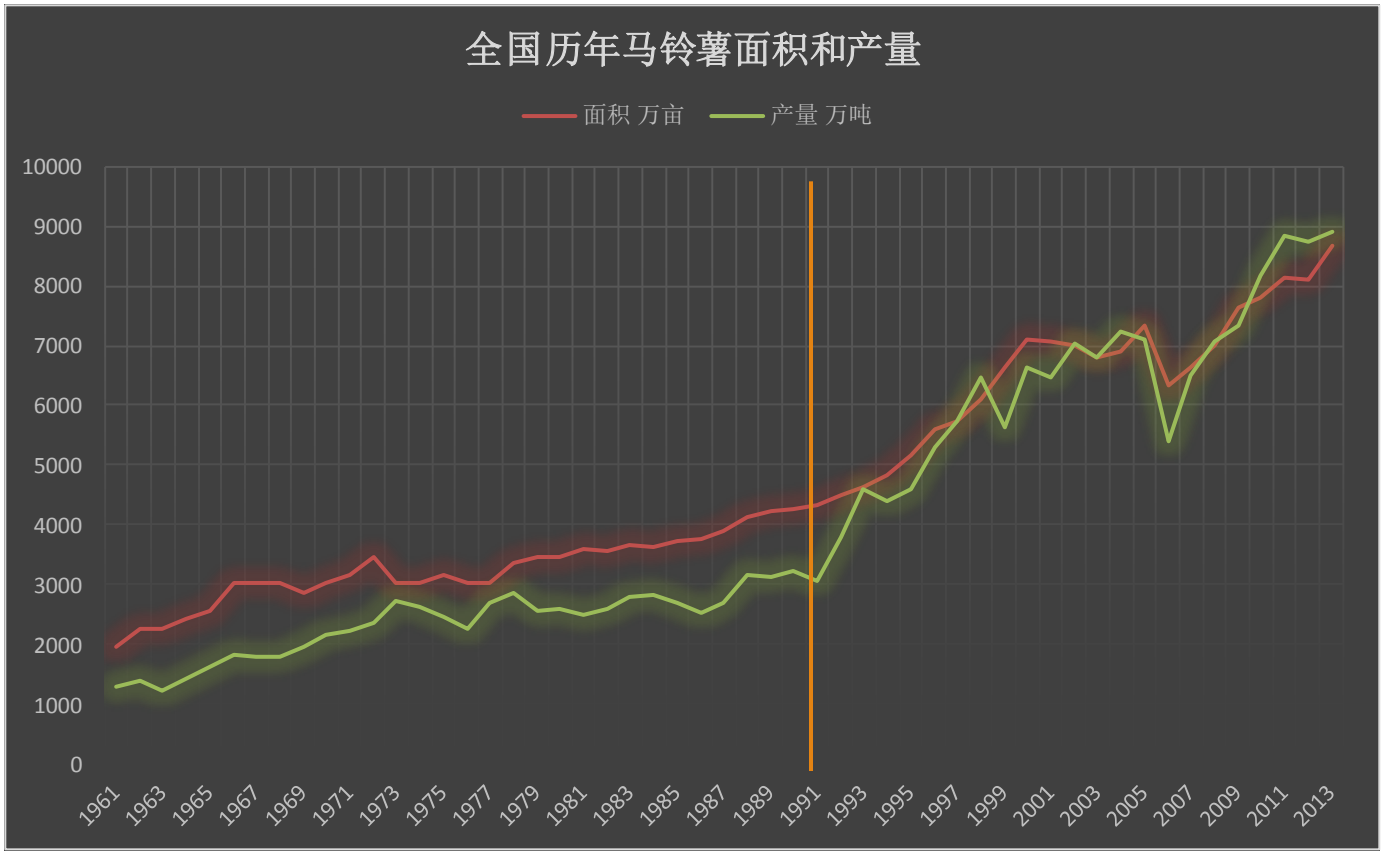


Proportion of production by region



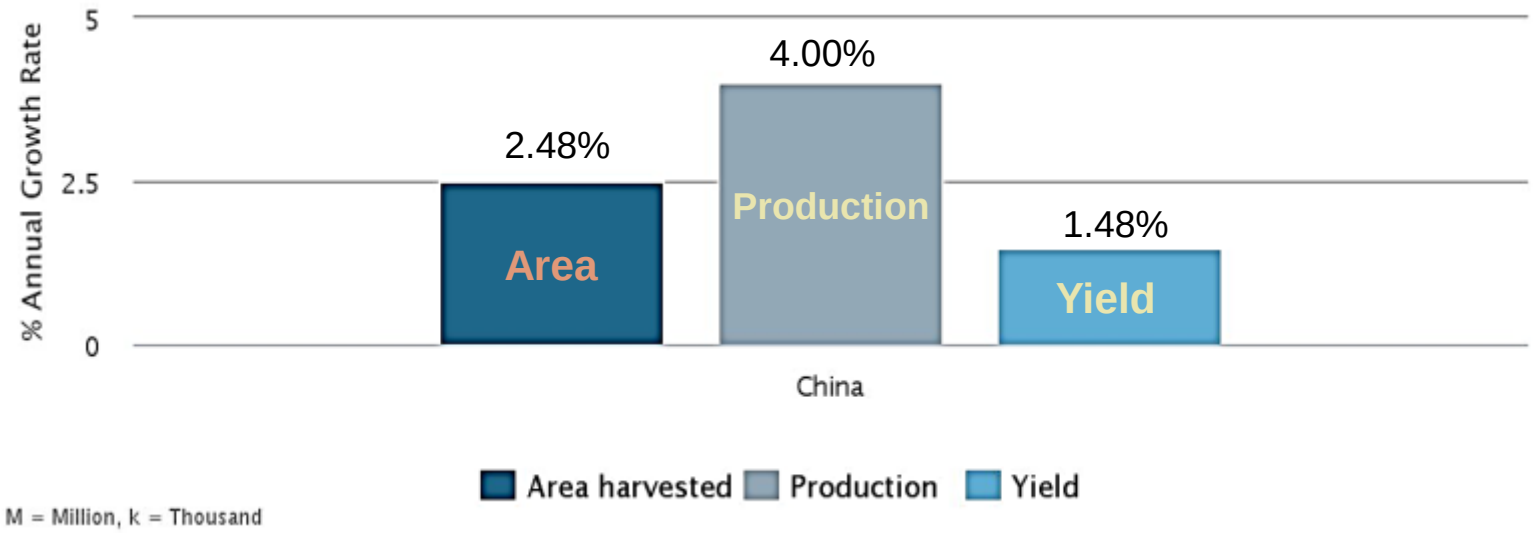
2011 China Agriculture Statistical Report

Production 1961-2014



Retrived from FAOSTA，2015

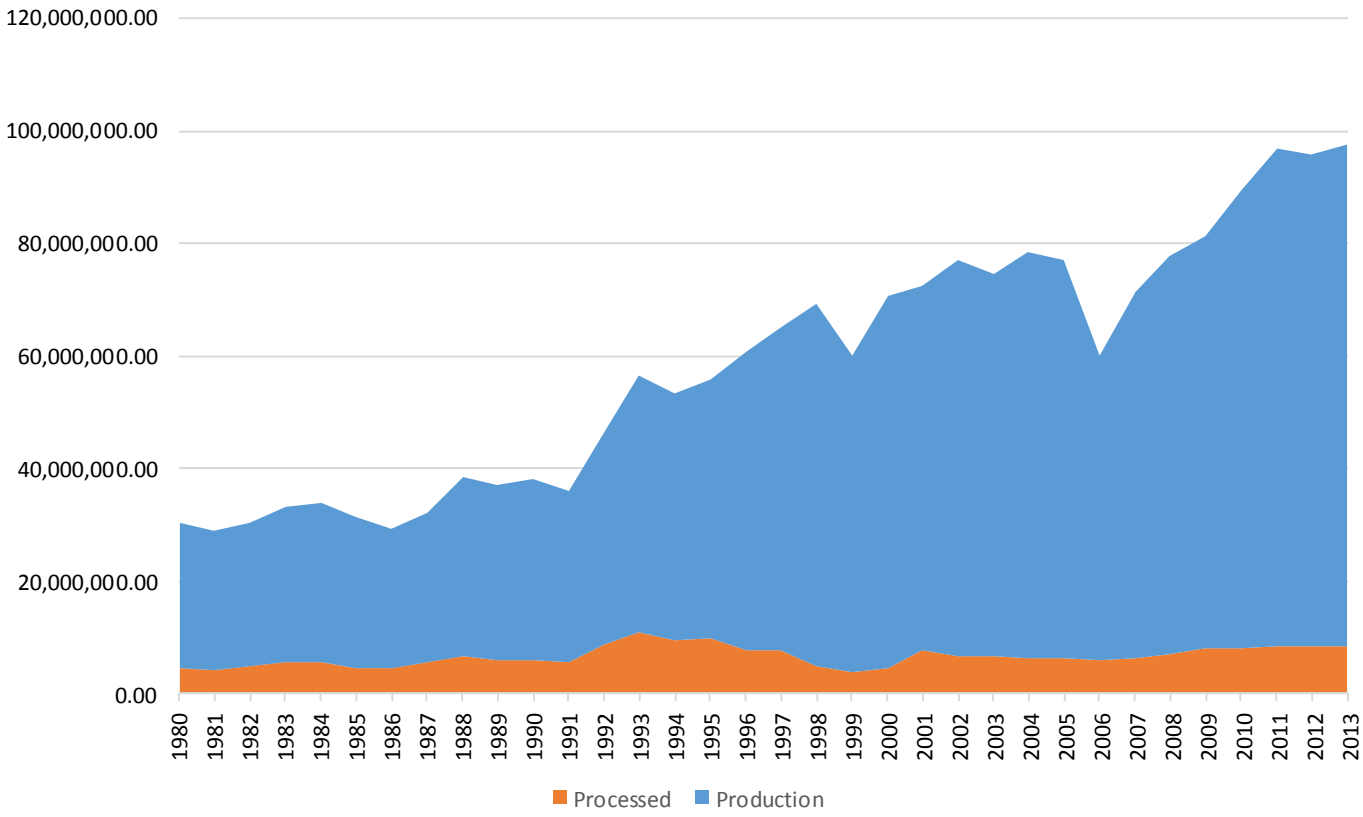
Annual Growth Rate 1993-2013



Retrived from FAOSTA，2015

Amount of potatoes for processing

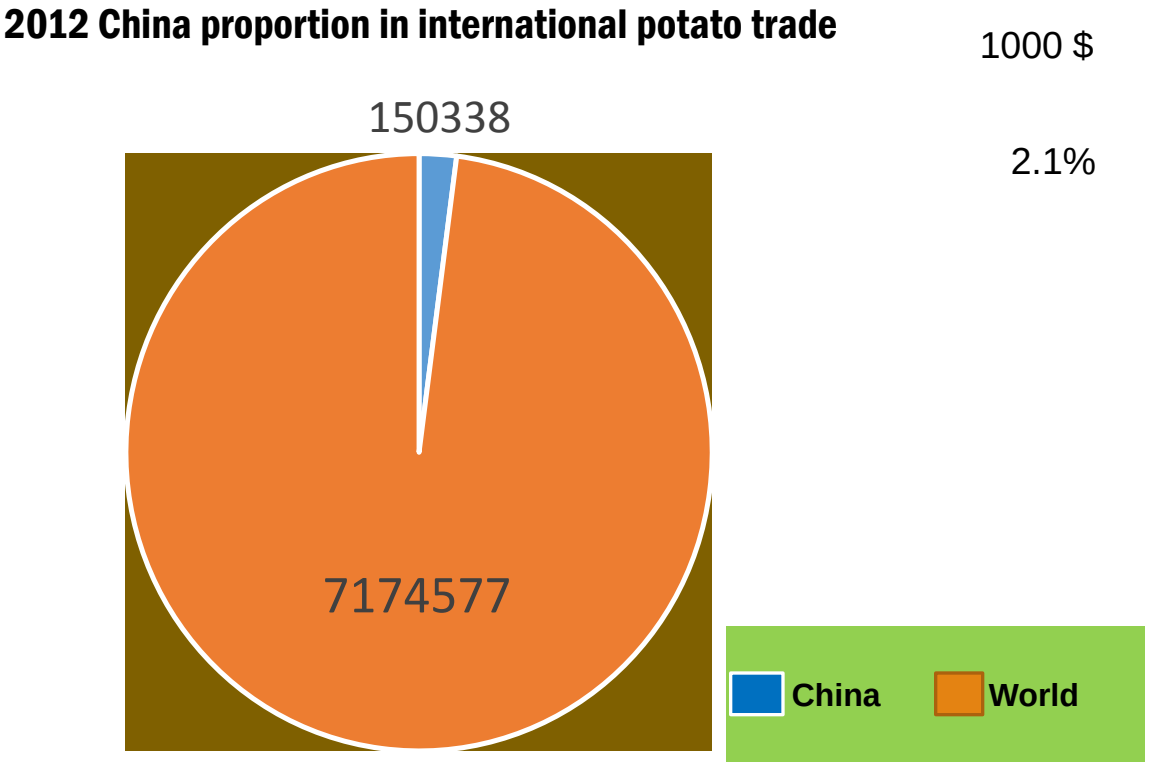
- Processing potato increased rather slowly



http://www.potatopro.com/china/potato-statistics retrieved from FAOSTAT, 2015

Potato trade in China

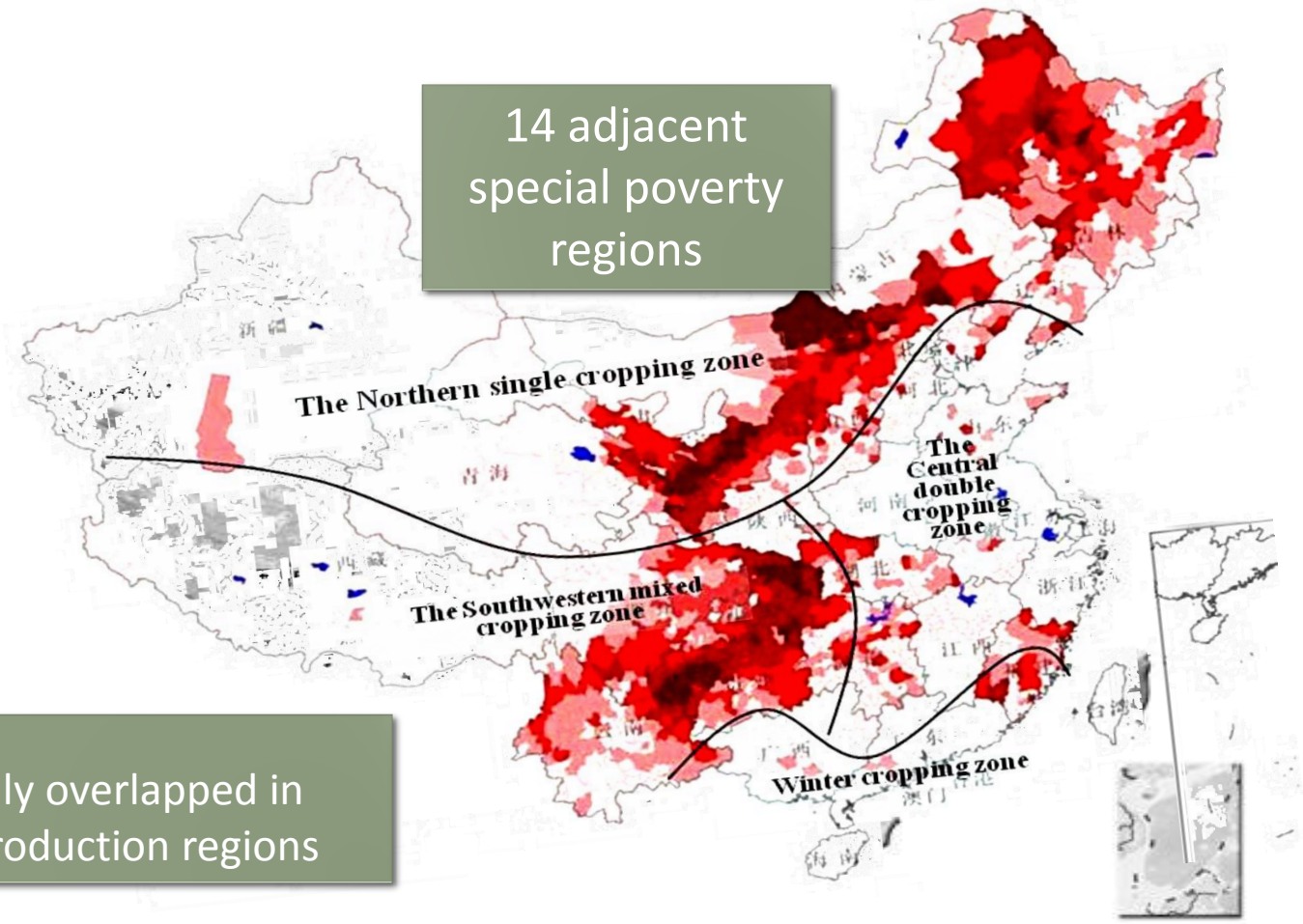
- Trade： great market potential



FAOSTA, 2015

Importance for poverty-alleviation

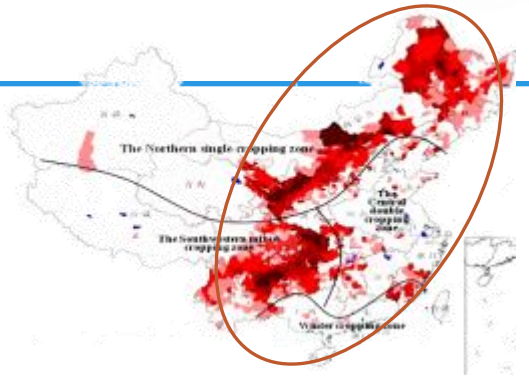
14 adjacent special poverty regions



10 of them are highly overlapped in the major potato production regions

From anonymous

I. Durable resistance to LB



Late blight

I. Durable resistance to LB

- More than 30 R genes have been cloned

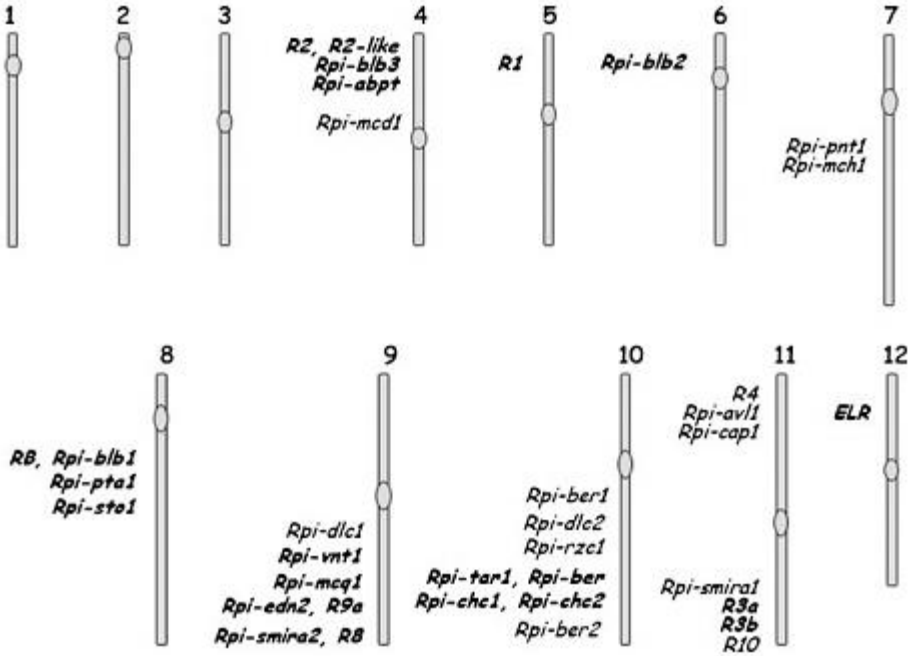
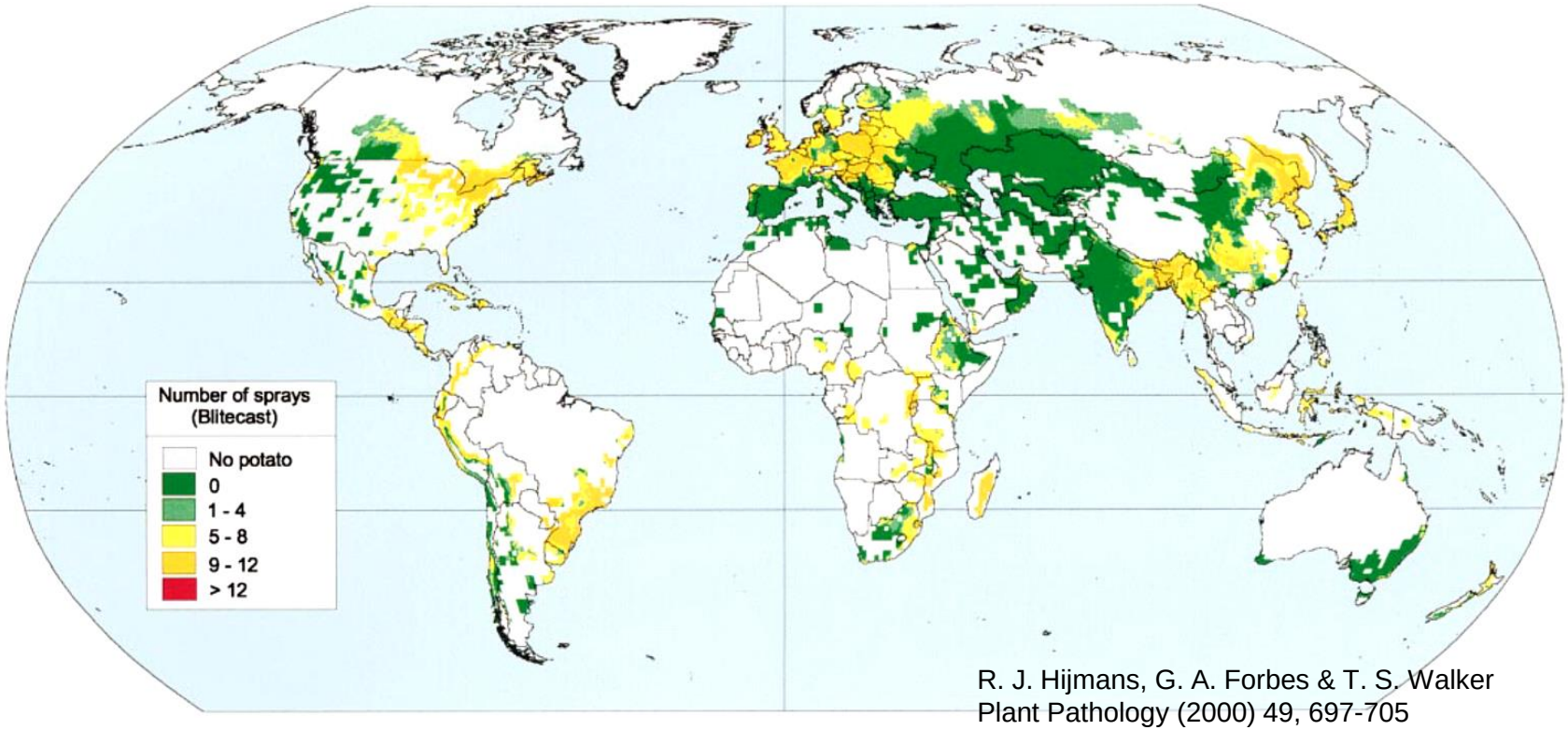


Fig. 1 *R* genes mapped (*regular font*) and cloned (*bold font*) as described in the literature completed with unpublished DuRPh results. *Vertical bars* represent the 12 chromosomes of potato

A. J. Haverk et al. Potato Research (2016) 59:35–66

I. Durable resistance to LB

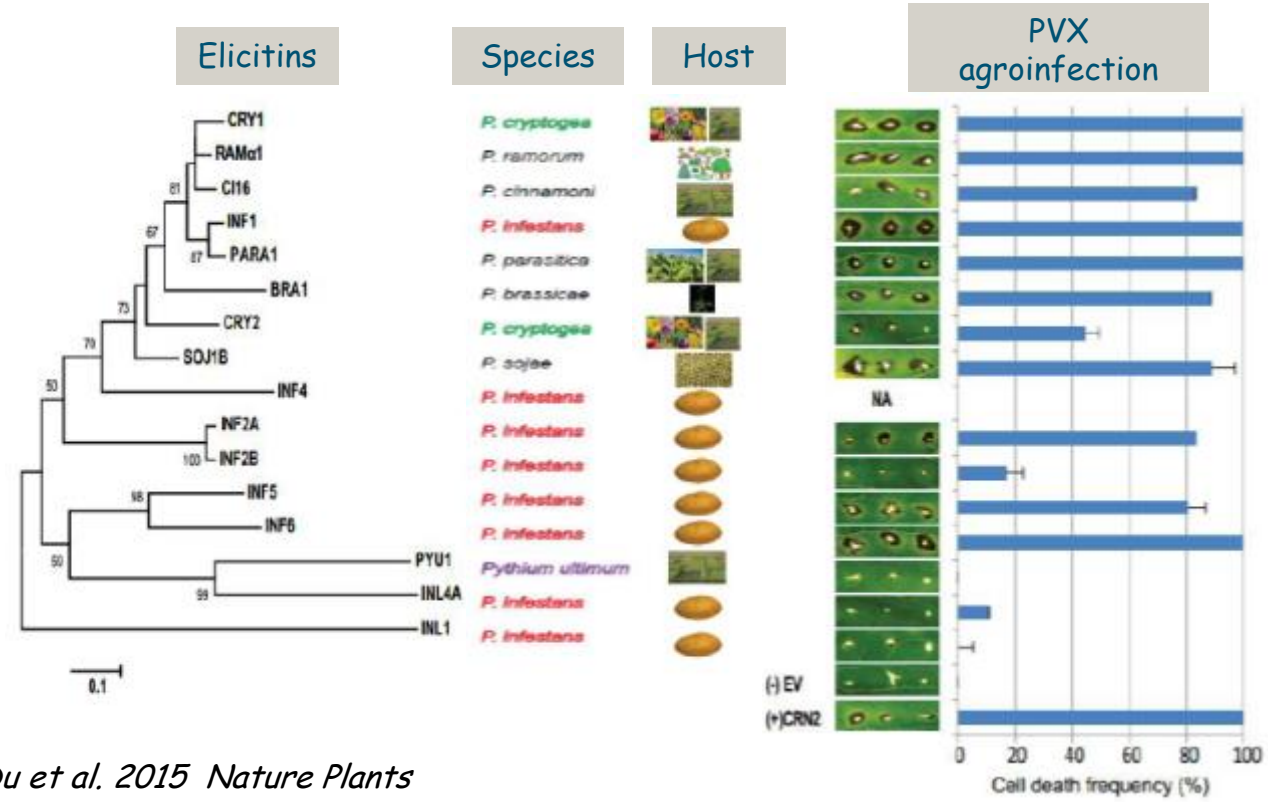
- Most identified R genes have been defeated by fast evolved pathogen



R. J. Hijmans, G. A. Forbes & T. S. Walker
Plant Pathology (2000) 49, 697-705

I. Durable resistance to LB

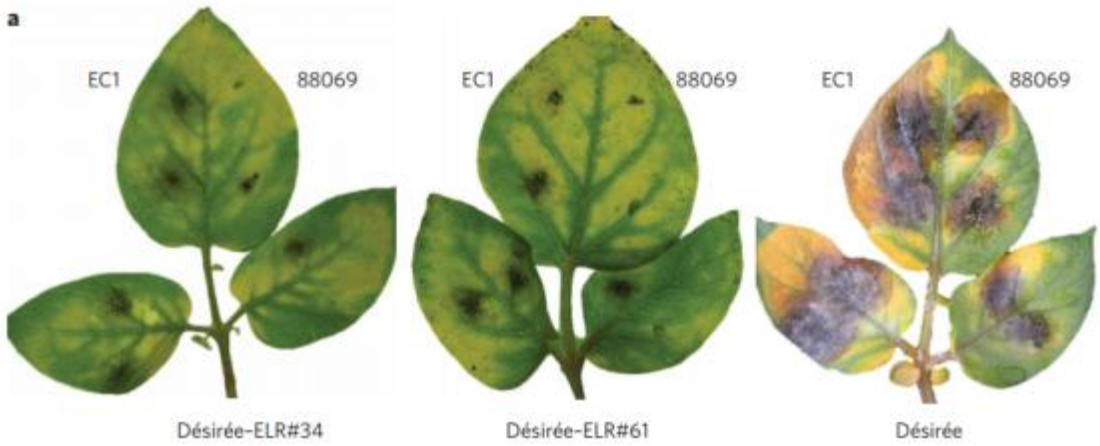
Potato transformants of *ELR* recognize broad-spectrum of *Phytophthora* elicitins



Du et al. 2015 Nature Plants

I. Durable resistance to LB

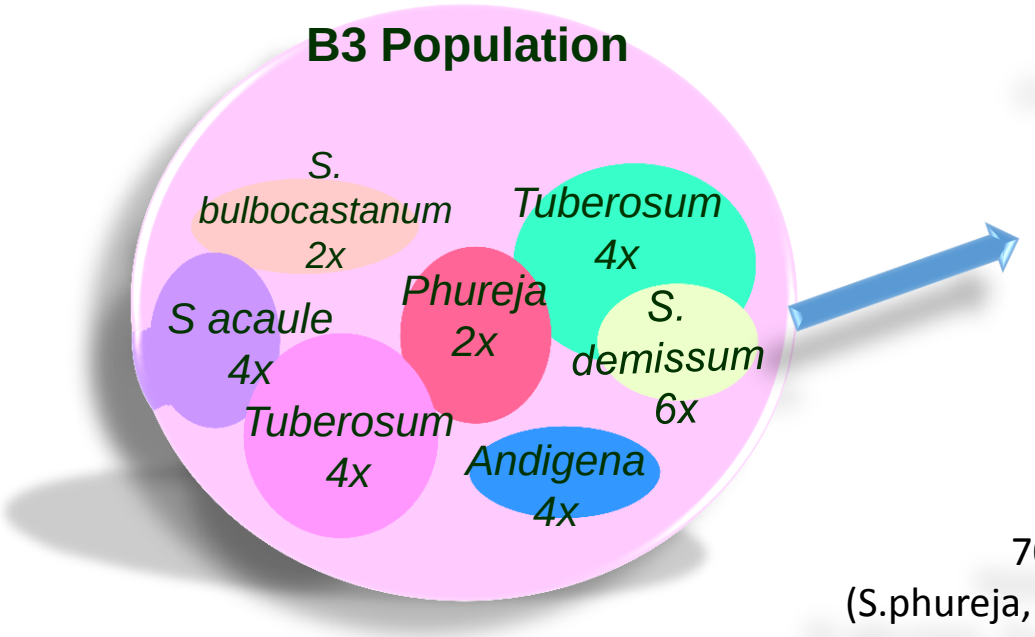
ELR confers enhanced late blight resistance



6 dpi

Du et al. 2015 Nature Plants

I. Durable resistance to LB



From M. Bonierbale

QTL mapping population

CIP386209.10 4X,B3C0 × CIP701241 (Huagalina)

393046.7 (4X, B3C1) ×

IVP35

703308 ♂ (S.phureja, Susceptible) × ♀ 301071.3 (Resistant Haploid)

F1 (B3C1HP, 100 ind)

I. Durable resistance to LB

Field phynotyping of late blight resistance

703308	10	45	100	100	100	100	100	3628
[(393046.7 x IVP35)3 x 703308)1	5	10	20	20	20	20	20	745
[(393046.7 x IVP35)3 x 703308)1	5	20	20	20	20	30	30	925
[(393046.7 x IVP35)3 x 703308)1	10	20	2				25	
[(393046.7 x IVP35)3 x 703308)1	10	15	2				20	
[(393046.7 x IVP35)3 x 703308)10	5	15	2				65	1355
[(393046.7 x IVP35)3 x 703308)10	5	30	35	45	75	80	85	2248
[(393046.7 x IVP35)3 x 703308)10	10	35	45	65	75	80	85	2525
[(393046.7 x IVP35)3 x 703308)10	10	30	30	30	45	85	85	1930
[(393046.7 x IVP35)3 x 703308)100	0	0	0	0	0	5	10	70
[(393046.7 x IVP35)3 x 703308)100	0	0	0				10	70
[(393046.7 x IVP35)3 x 703308)100	0	0					15	
[(393046.7 x IVP35)3 x 703308)100	0	0					10	
[(393046.7 x IVP35)3 x 703308)11	0	0	0	0	0	5	5	53
[(393046.7 x IVP35)3 x 703308)11	0	0	0	0	0	5	5	53
[(393046.7 x IVP35)3 x 703308)11	0	0	0	0	5	5	20	143
[(393046.7 x IVP35)3 x 703308)11	0	0	0	0	0	5	15	88
[(393046.7 x IVP35)3 x 703308)12	0	0	0	0	5	5	15	125
[(393046.7 x IVP35)3 x 703308)12	0	0					30	213
[(393046.7 x IVP35)3 x 703308)12	0	0					20	
[(393046.7 x IVP35)3 x 703308)12	0	0					5	
[(393046.7 x IVP35)3 x 703308)13	5	20	25	45	65	70	85	1958

A \ OXA09-21 / OXA07-14 / OXA06-17 / COM07-14 / COM06-17 /

x.xls

III

II

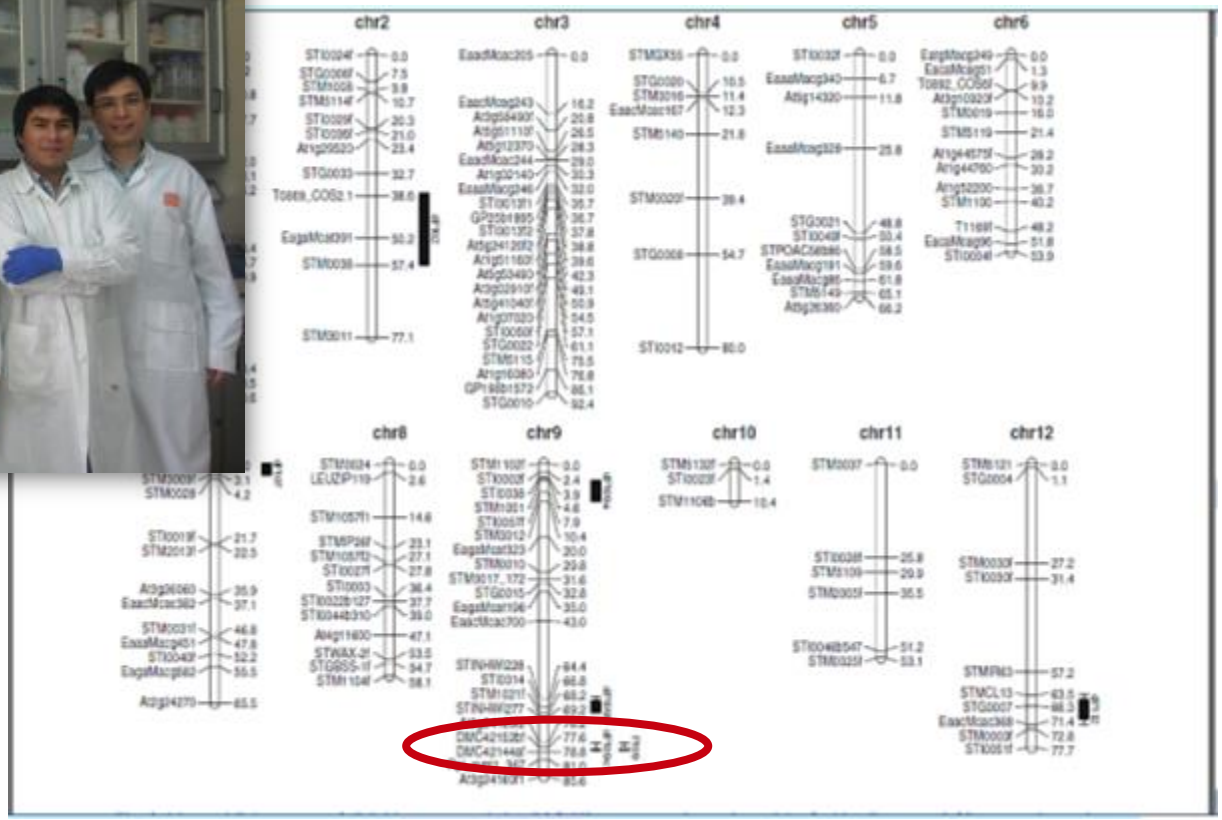
I

Oxapar

Coma

Coma

QTL for LB resistance

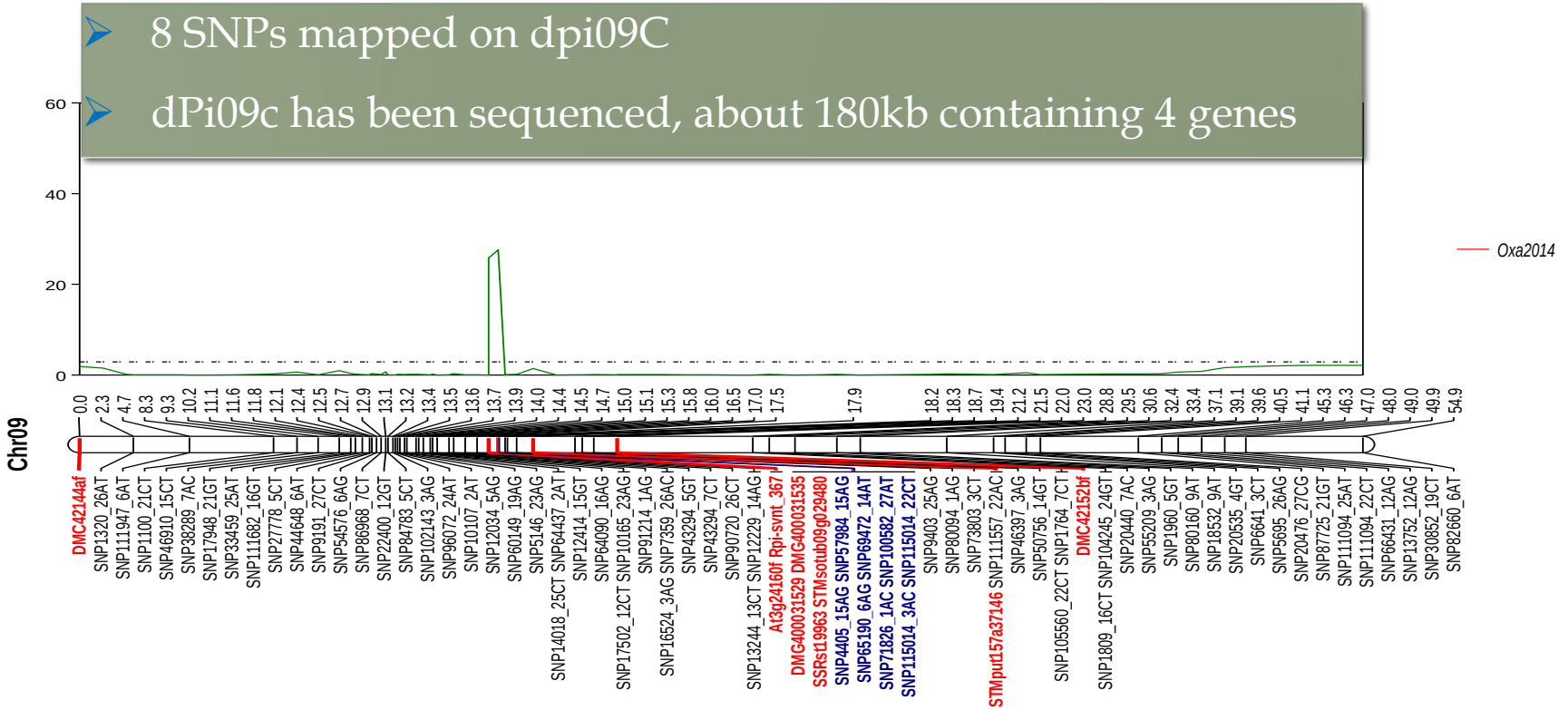


Li, et al, TAG. 2012

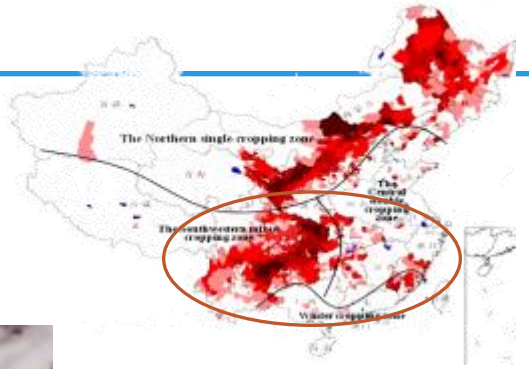
I. Durable resistance to LB

High-density map of dpi09C

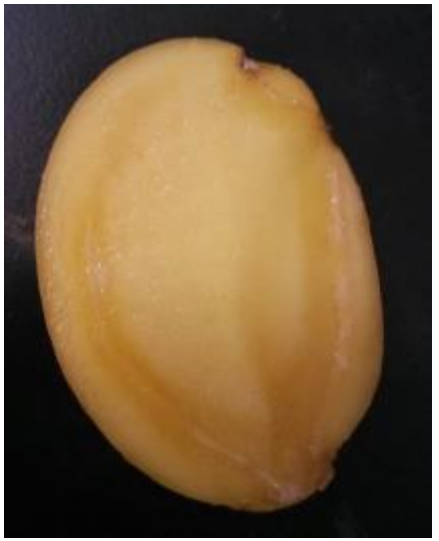
- 8 SNPs mapped on dpi09C
- dPi09c has been sequenced, about 180kb containing 4 genes



II. New source for BW resistance



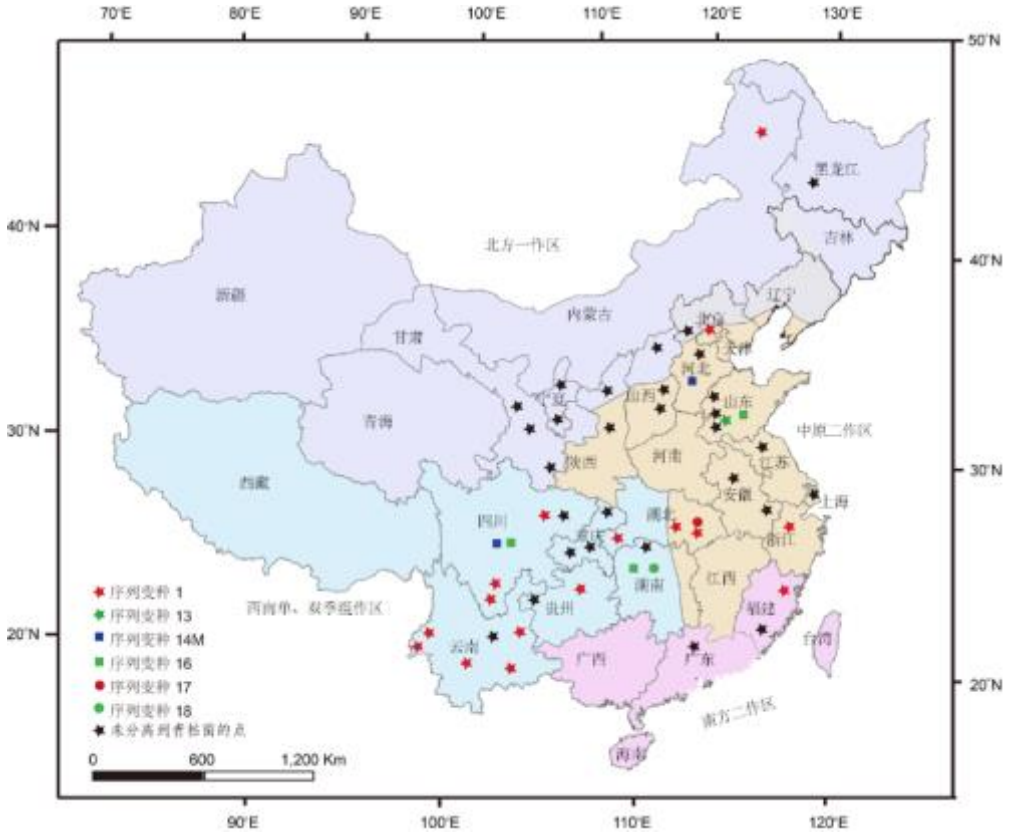
Bacterial wilt



II. New source for BW resistance

Pathogenicity and genetic diversity of *Ralstonia solanacearum* in China

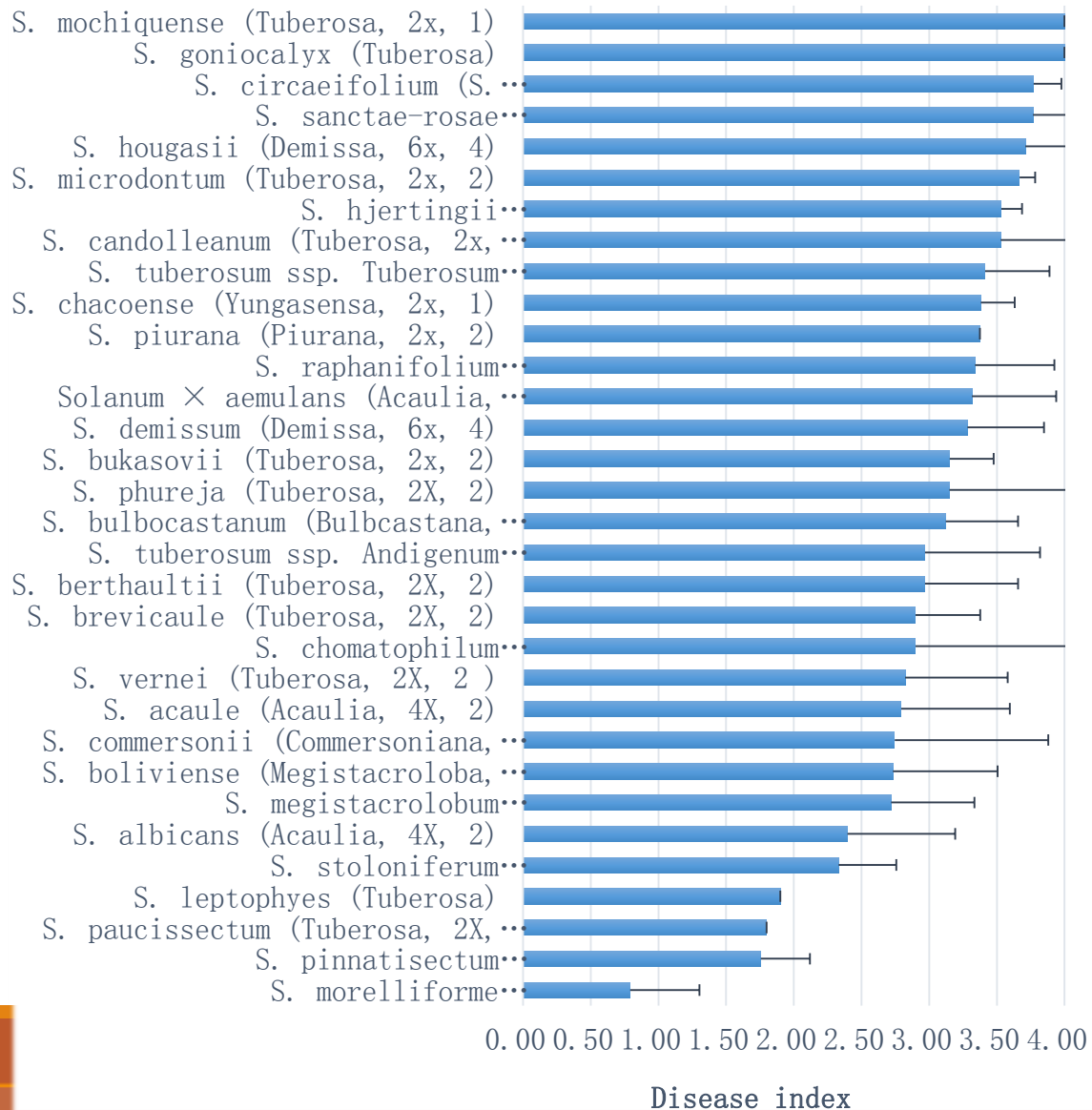
- 91% of 123 isolates belong to race 3 biovar 2 (R3Bv2), phylotype IIB sequevar 1 (IIB/1),



II. New source for BW resistance

Screening of resistant potato with *Ralstonia solanacearum* in phylotype IIB clade

- 316 potato acc. from 32 species were tested with *R. solanacearum* UW551 (IIB/1).
- 6 were resistant.
- *S. morelliforme* is the most resistant species .



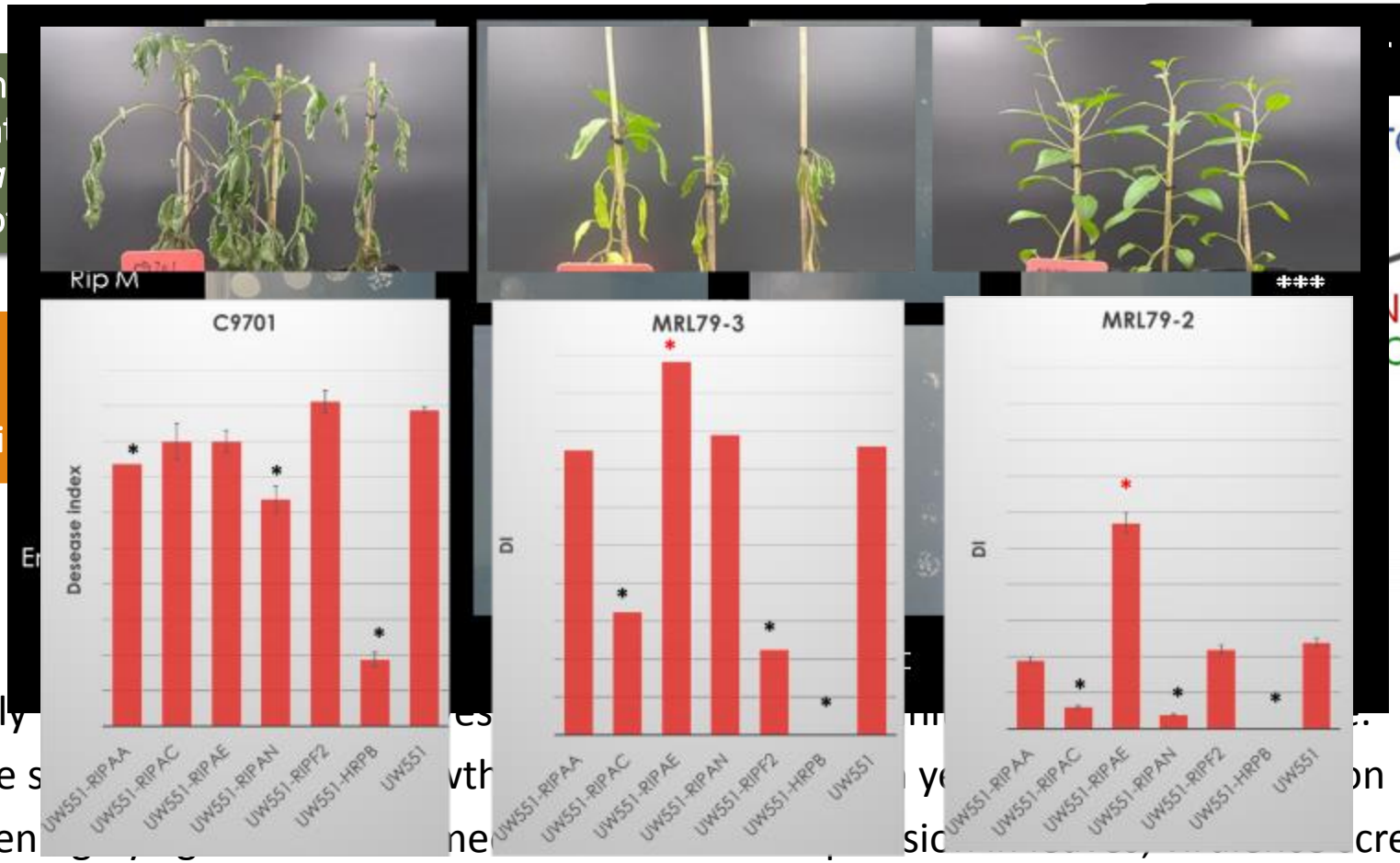
II. New source for BW resistance

Screen
virulent
Ralstonia
in phylo

probe

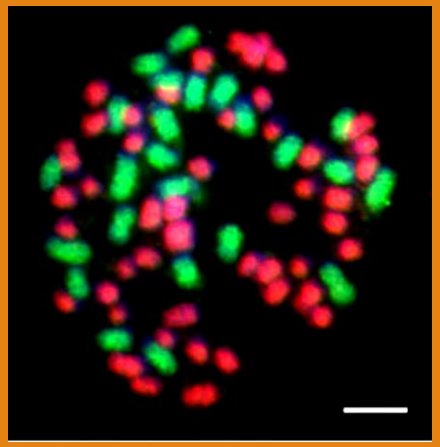
TORS

NSLOCON
CTISOME

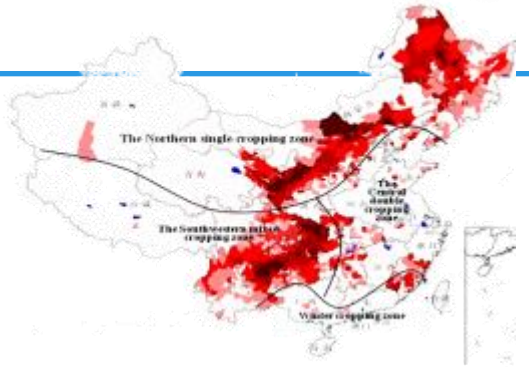


- highly
- three s vth y on screen ne sic creening by potato inoculation with effector mutants.

II. New source for BW resistance



III. New genes resistant to viruses



Viruses

- At least 18 viruses
- 1 viroid
- Mainly mosaic, leaf roll

III. New genes resistant to viruses

- ***Rychc* is extremely resistance to PVY**
- ***Rychc* has been mapped to a 120 kb region on chromosome 9**

Chc (40-3) *tar*

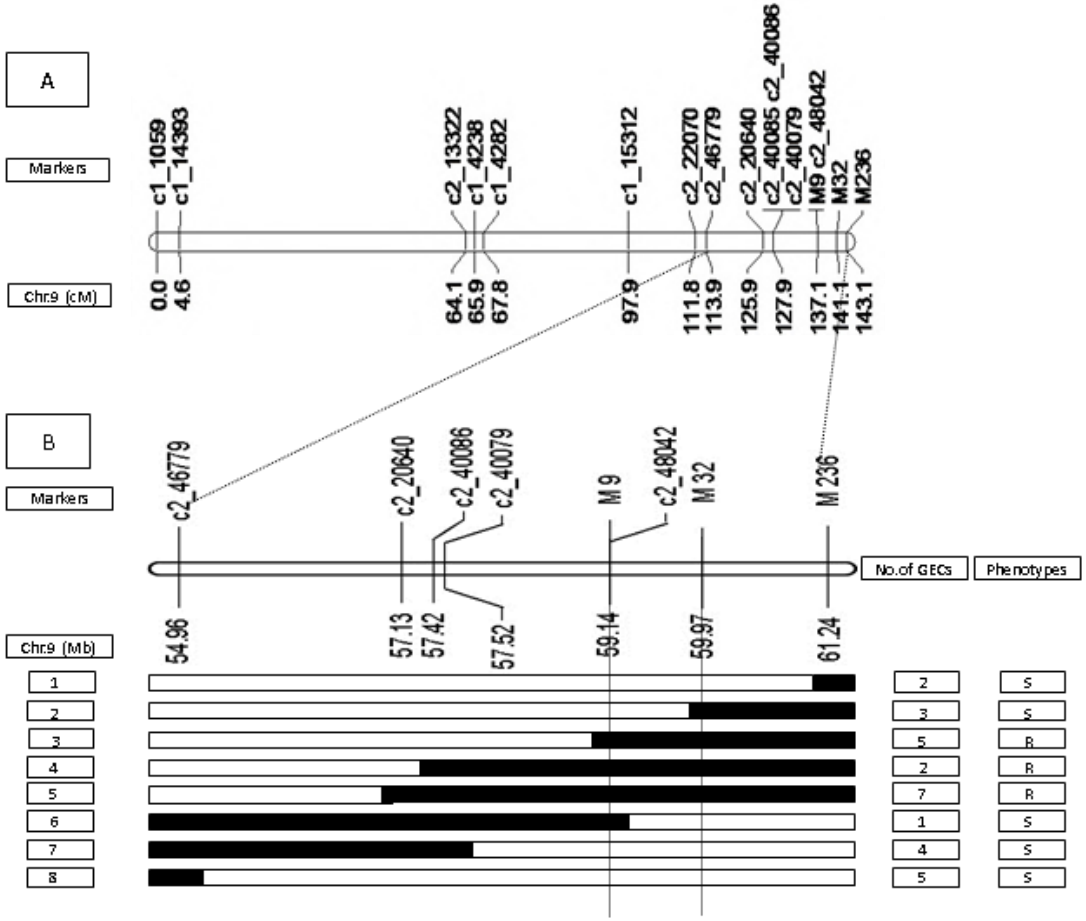
R (♀) × S (♂)

↓

F_1

↙ ↘

R (91) S (84)

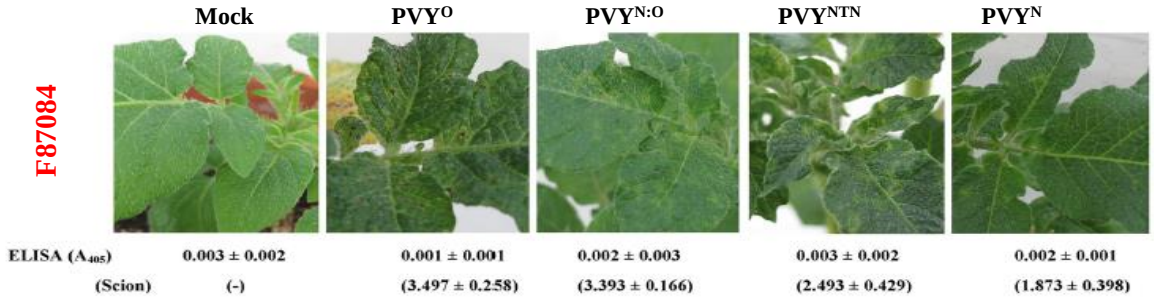


III. New genes resistant to viruses

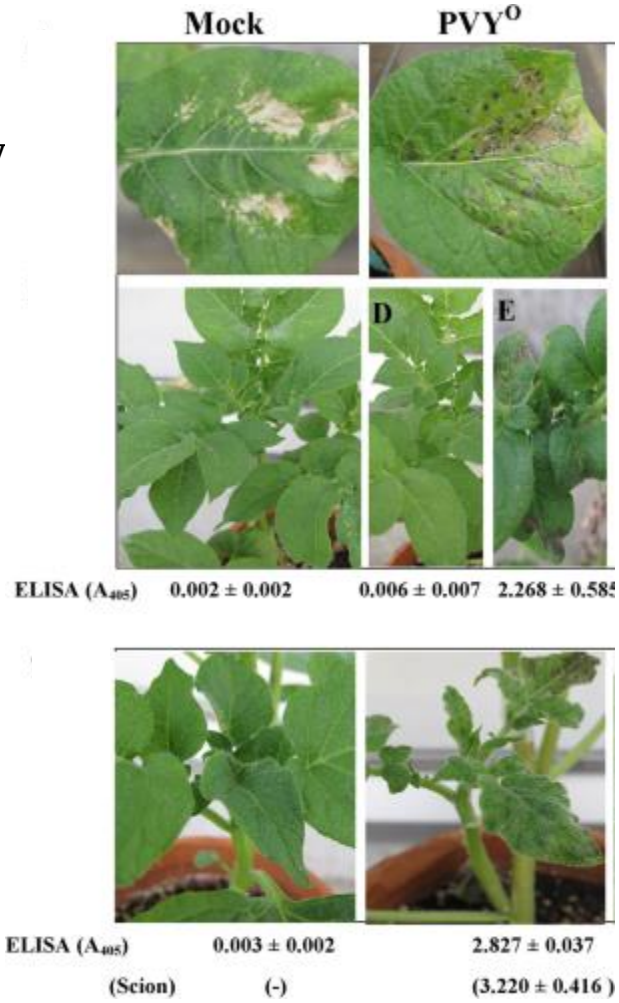
Ry and *Ny* in potato

Extreme resistance in F87084 to all PVY strains (below hypersensitive resistance in Exploits to PVY^{O} (right)

Nie X et al., 2015, Am J Potato Res, 92:23-31



Exploits



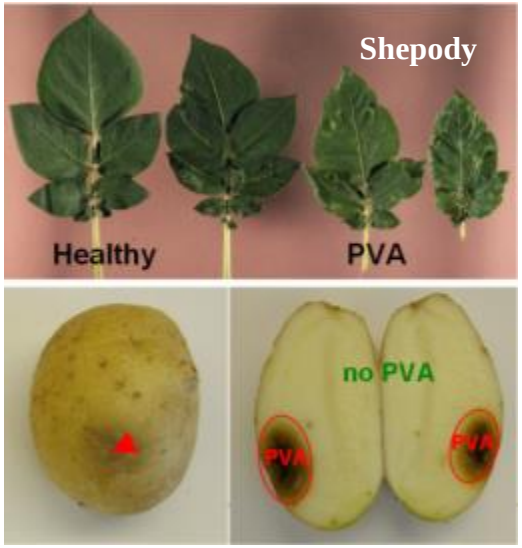
III. New genes resistant to viruses

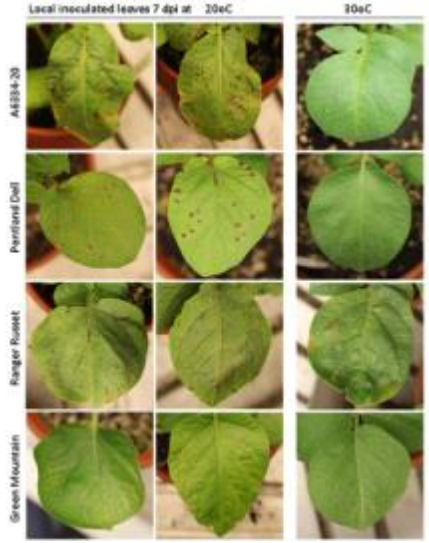
_Ra, Ny, Nx_ in potato

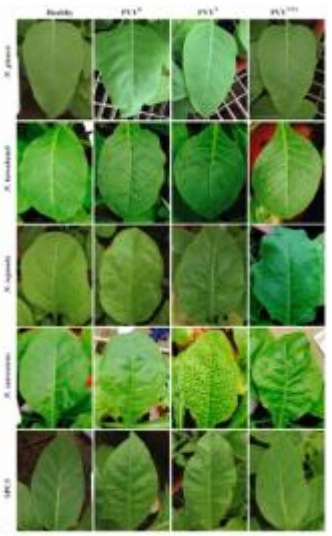
Extreme resistance in Shepody and Barbara against PVA, and HR in A6334-14, Pentland Dell and Ranger Russet against PVA and/or PVX.

_Ry, Rs_ in tobacco and potato

Screening for PVY resistance in 58 tobacco wild species; and screening for PVS resistance in over 200 potato wild species.







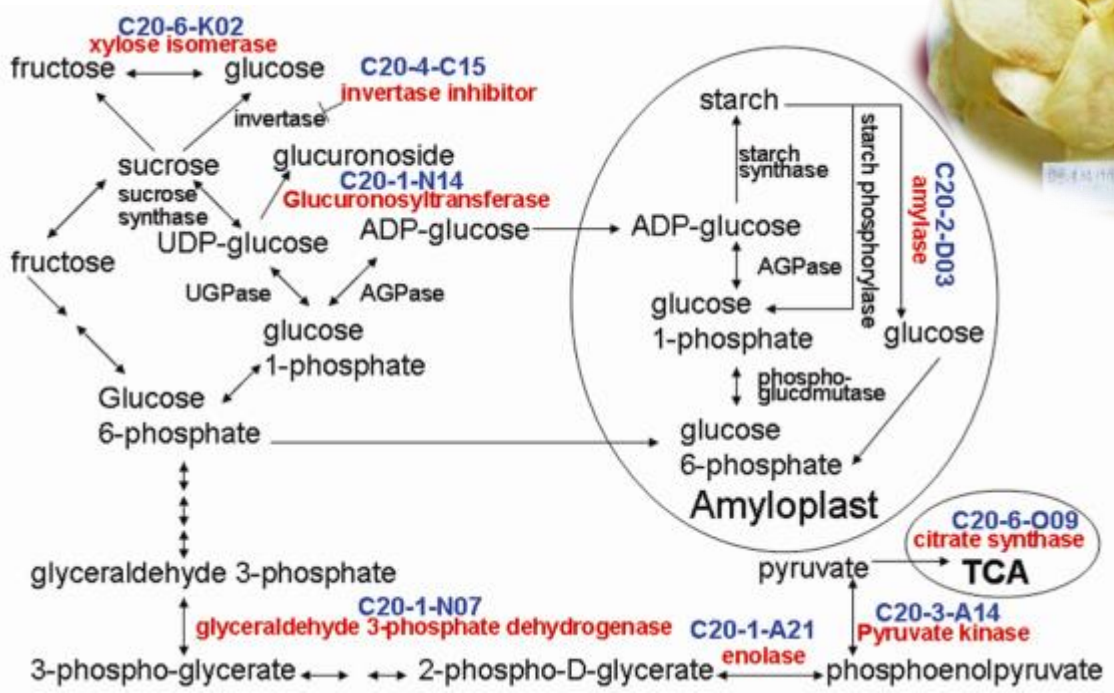
III. New genes resistant to viruses

Other works on viruses

- **Diversity of Potato Viruses:** characterize virus genomics/virology; diversity and evolution of potato viruses;
- **Diagnosis of Potato Viruses:** RT-PCR for simultaneous detection of multiple viruses; enotyping/differentiation of virus strains; RPA for detection of multiple viruses by isothermal amplification; NGS and bioinformatics;
- **Potato-Viruses Interactions:** Resistance inheritance; MAS; Symptoms response to viruses/virus strains; differentially expressed genes (DEGs) during potato-virus interactions

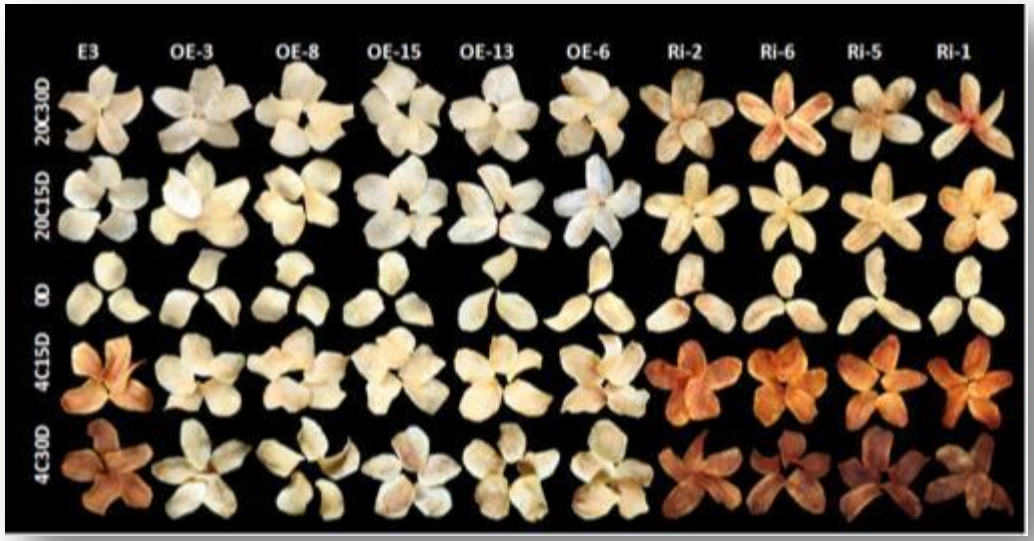
Other works in HZAU

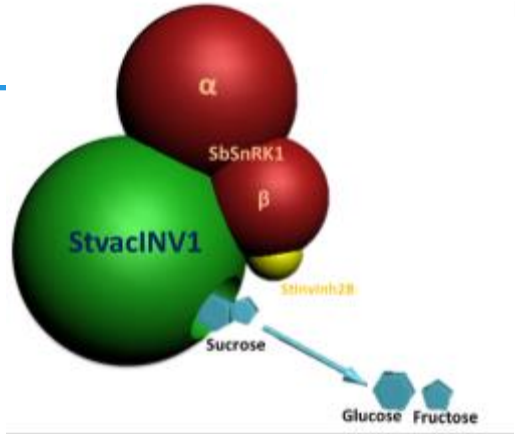
Cold induced sweetening



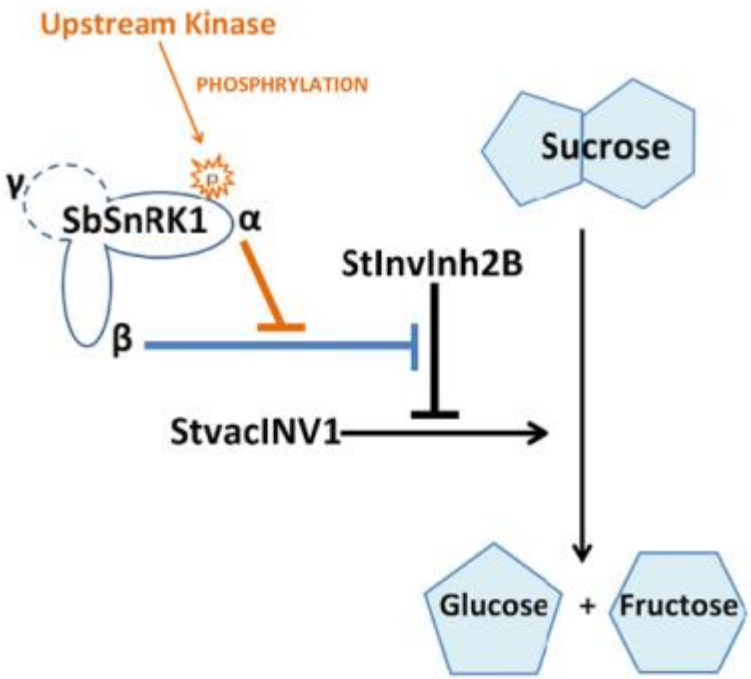
Liu et al. MGG. 2010; Liu et al. MGG. 2011

Regulation of invertase activity



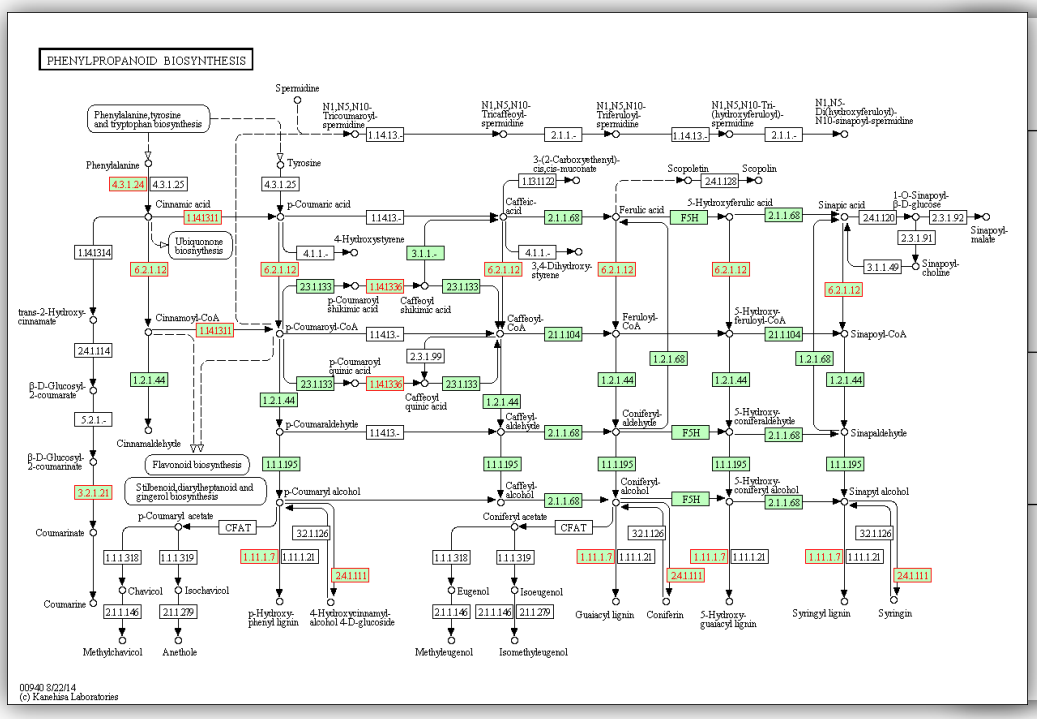


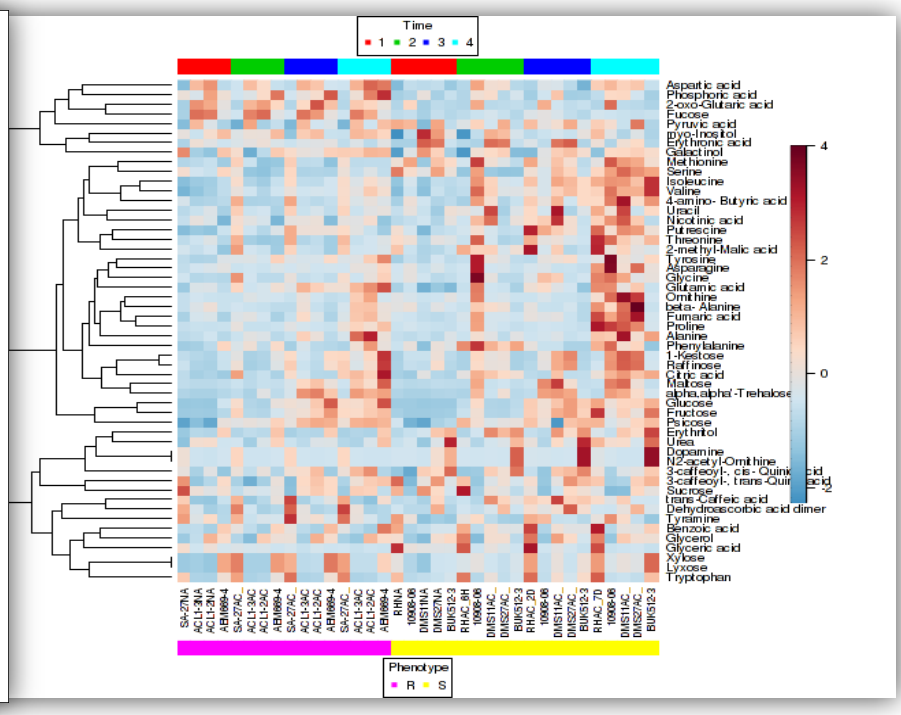
SbSnRK1a improved the chip colour in storage of 4℃ 15 days and 30 days .



Lin et al. Plant Physiology. 2015

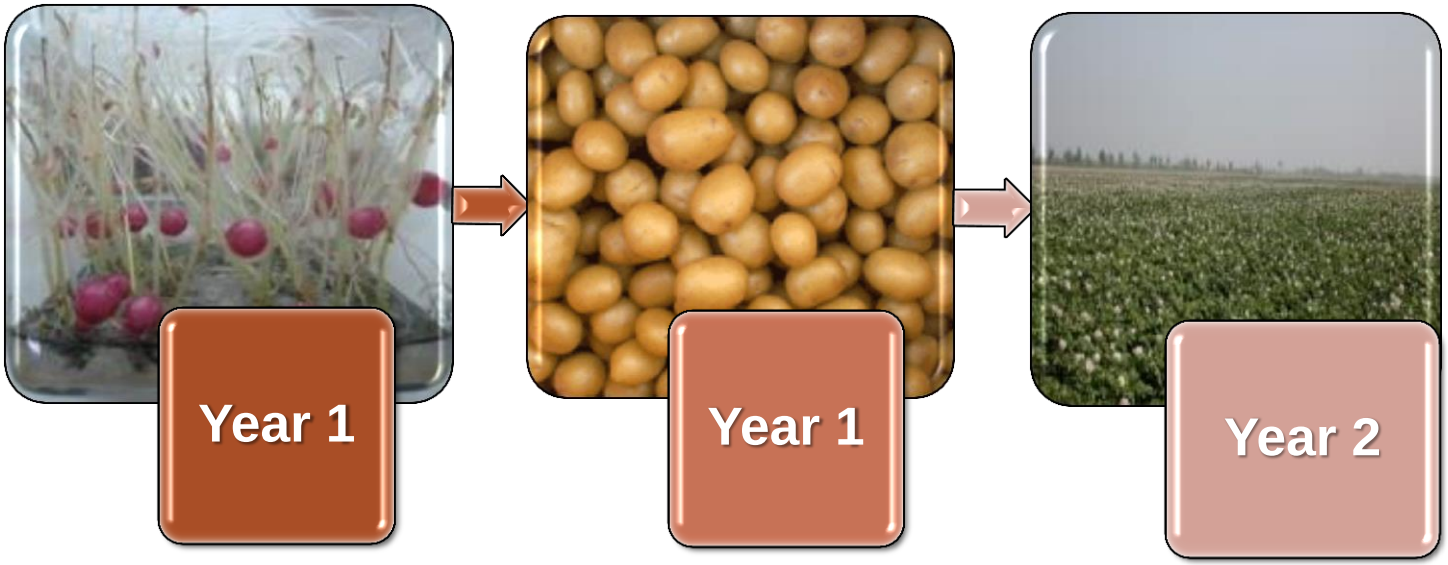
Frost-resistance





Tuber development

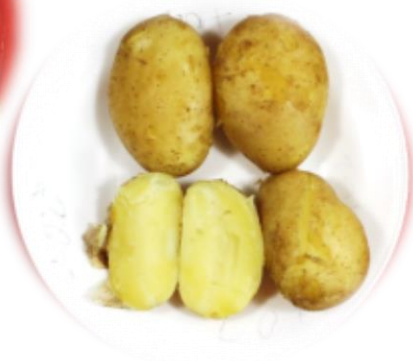
Microtuber-based seed potato system



Potato breeding

Huashu 1

Huashu 2



Huashu 3

Clones ready for variety registration

05HE5-43

F0 CA0623

08CA9728-04

Long and active international collaborations

Long and active international collaboration

Long and active international collaboration

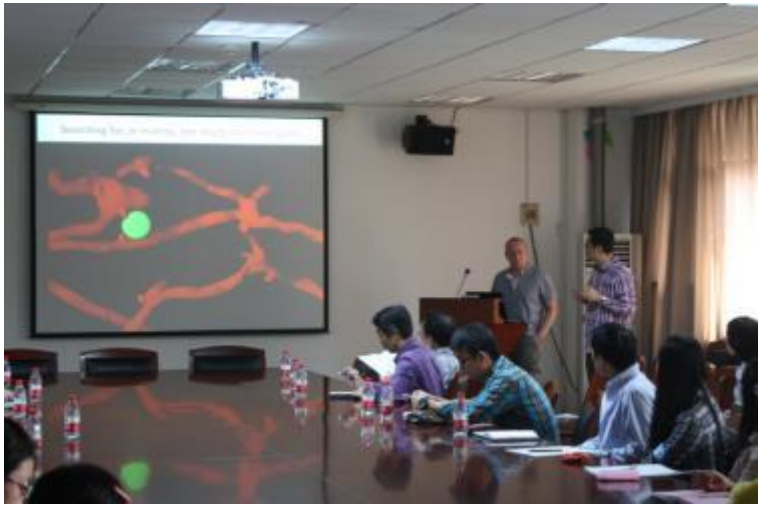
Professor Jeff Moorby

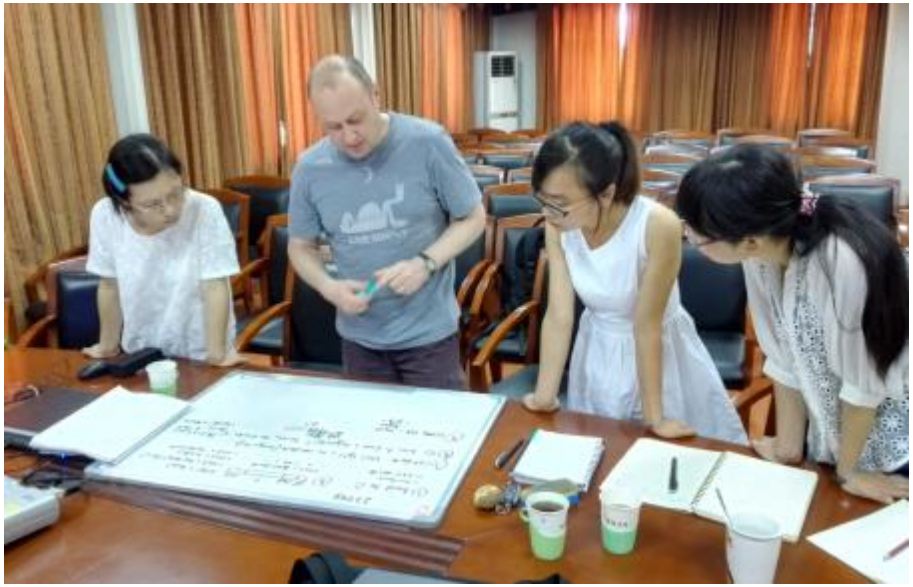
HZAU & JHI

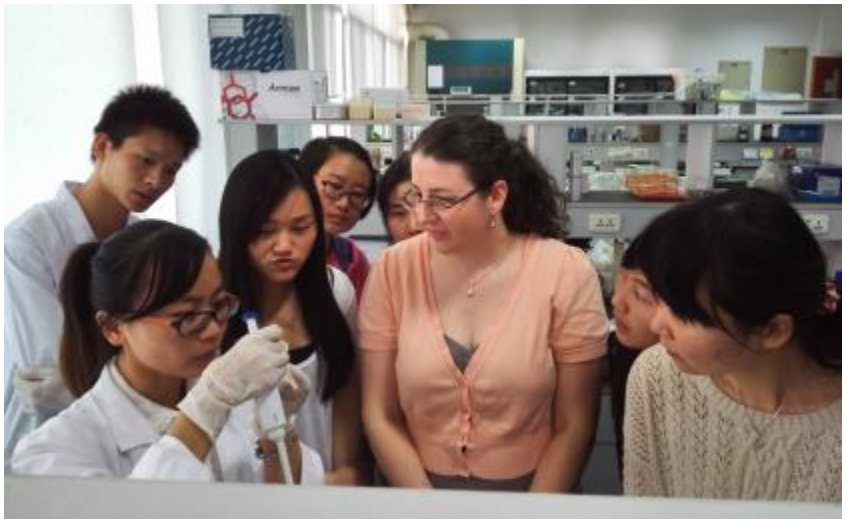
2008-2009 Tian Z, Postdoc, SCRI
2011 7.3-8 Paul Birch, Stephen Whisson, HZAU,
2012 5.19-21 Paul Birch, Ingo Hein, Eleanor Gilroy, Stefan Engelhardt , Susan Breen, HZAU
2012 7 Xie C, Liu J, ian Z, Li J, JHI
2013 4.22-5.5 Paul Birch, HZAU 9.28-10.5 Jennifer Stephens, HZAU
2014 10.14-18 Ingo Hein, HZAU
2014 8.14-22 Tian Z, JHI
2015 High-end Foreign Experts Recruitment Program
Paul Birch， Petra Boevink， Ingo Hein， Hazel Mclellan, Ian Toth, HZAU
2016 Paul Birch, twice to HZAU
2013.11-2015.10 He Qin, PhD programme, 3 of 6 month, JHI
2016.5-2016.11 Wang H, PhD programme, JHI
2016.5- He Qin, Postdoc


scri
Reception

2011 7.3-7.8 Paul Birch Stephen Whisson







Joint publications:

1.Boevink PC, McLellan H, Gilroy EM, Naqvi S, **He Q**, Yang L, Wang X, Turnbull D, Armstrong MR, **Tian Z**, Birch PR. Oomycetes Seek Help from the Plant: *Phytophthora infestans* Effectors Target Host Susceptibility Factors. Mol Plant. 2016, 9(5): 636-638.

2.Yang L, McLellan, H, Naqvi S, **He Q**, Boevink PC, Armstrong M, Giuliani LM, **Zhang W**, **Tian Z**, Zhan J, Gilroy EM, Birch PRJ. Potato NPH2/RPT2-like protein StNRL1, targeted by a *Phytophthora infestans* effector, is a susceptibility factor. Plant Physiol. 2016, 171: 645-657

3.He Q, McLeIlan H, Boevink P, C Sadanandom A, Xie CH, Birch P R J, Tian ZD. U-BOX E3 ubiquitin ligase PUB17 acts in the nucleus to promote specific immune pathways triggered by *Phytophthora infestans*. J Exp Bot, 2015, 6611: 3189-3199

4.Boevink P C , Wang X D, McLeIlan, He Q, Armstrong M, Naqvi S, Armstrong M R, **Wei Zhang**, Hein I, Gilroy E M, **Tian Z D**, Birch P R J*. A P. infestans RXLR effector targets plant PP1c isoforms that promote late blight disease. 2015, Nat Commun. DOI: 10.1038/ncomms10311

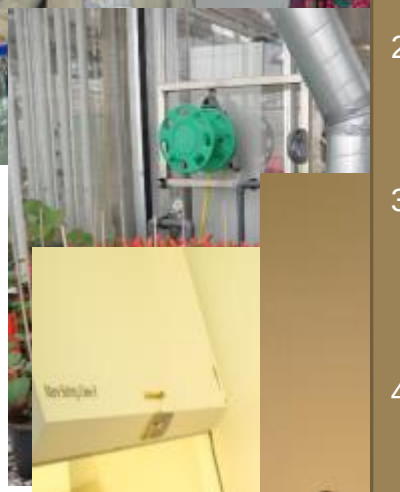
5.Ramesh R. Vetukuri, **Zhendong Tian**, Anna O. Avrova, Eugene I. Savenkov, Christina Dixelius, Stephen C. Whisson. Silencing of the PiAvr3a effector-encoding gene from Phytophthora infestans by transcriptional fusion to a short interspersed element. Fungal Biology, 2011, 115(12): 1225-33

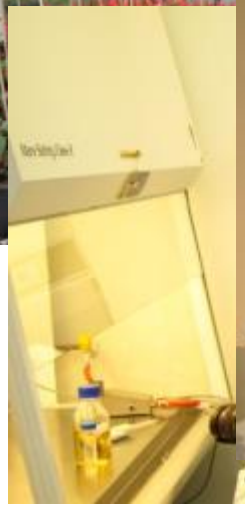
6.Bos J, Armstrong M, Gilroy E M, Boevink P C, Hein I, Taylor R M, **Tian Z D**, Vetukuri R R, Harrower B, Bryan G, Sadanandom A, Whisson S C, Kamoun S, Birch P R . Essential Phytophthora infestans effector AVR3a manipulates plant immunity by stabilizing host U-box protein CMPG1. Proc. Natl. Acad. Sci. U.S.A. 2010, 107（21）: 9909–9914

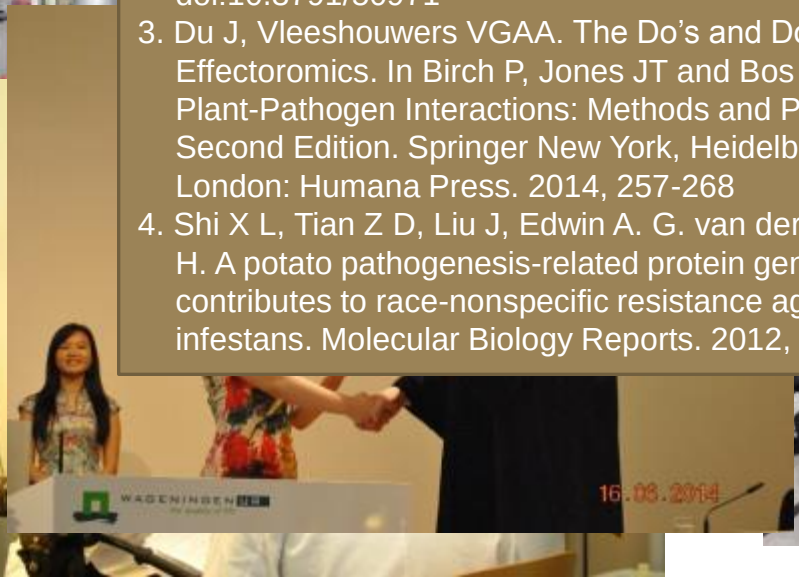
with Friedrich-Alexander-Universitaet Erlangen-Nürnberg & Max-Planck Institute for Plant Breeding Research

Lin Y, Y Liu T, Liu J, Liu X, Ou Y, Zhang H, Li M, Sonnewald U, Song B, Xie C. Subtle regulation of potato acid invertase activity by a protein complex of StvacINV1-StInvInh2B-SbSnRK1. *Plant Physiology*. 2015, 168: 1807-1819.

with WUR

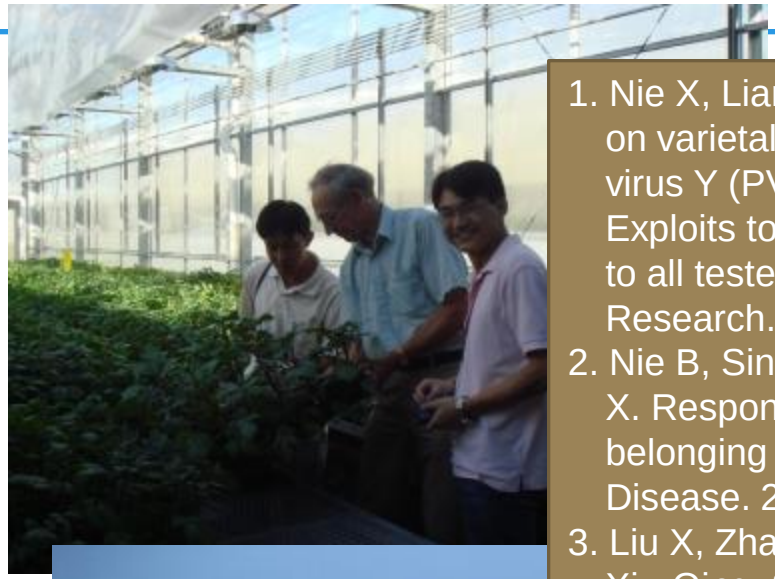


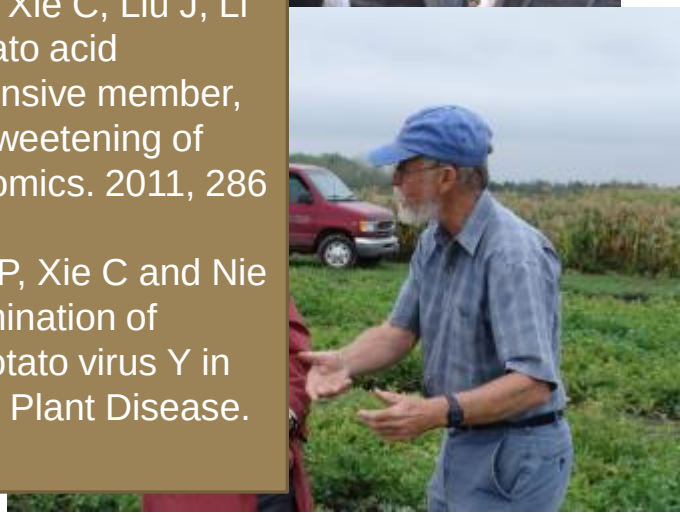




1. Du J, Verzaux E, Chaparro-Garcia A, Bijsterbosch G, Keizer LCP, Zhou J, Liebrand TWH, Xie C, Govers F, Robatzek S, van der Vossen EAG, Jacobsen E, Visser RGF, Kamoun S, Vleeshouwers VGAA. Elicitin recognition confers enhanced resistance to Phytophthora infestans in potato. Nature Plants. 2015, doi:10.1038/nplants.2015.34
2. Du J, Rietman H, Vleeshouwers VGAA. Agroinfiltration and PVX agroinfection in potato and Nicotiana benthamiana. Journal of Visualized Experiments, 2014, (83), e50971, doi:10.3791/50971
3. Du J, Vleeshouwers VGAA. The Do's and Don'ts of Effectoromics. In Birch P, Jones JT and Bos JIB (Eds), Plant-Pathogen Interactions: Methods and Protocols. Second Edition. Springer New York, Heidelberg, Dordrecht, London: Humana Press. 2014, 257-268
4. Shi X L, Tian Z D, Liu J, Edwin A. G. van der Vossen, Xie C H. A potato pathogenesis-related protein gene, StPRp27, contributes to race-nonspecific resistance against P. infestans. Molecular Biology Reports. 2012, 39:1909–1916

With Potato Research Center of AAFC





1. Nie X, Liang Z, Nie B, Murhpy A, Singh M. Studies on varietal response to different strains of Potato virus Y (PVY) reveal hypersensitive resistance in Exploits to PVYO and extreme resistance in F87084 to all tested strains. American Journal of Potato Research. 2015, 92:23-31
2. Nie B, Singh M, Murphy A, Sullivan A, Xie C, and Nie X. Response of potato cultivars to five isolates belonging to four strains of Potato virus Y. Plant Disease. 2012, 96:1422-1429
3. Liu X, Zhang C, Ou Y, Lin Y, Song B, Xie C, Liu J, Li Xiu-Qing. Systematic analysis of potato acid invertase genes reveals a cold-responsive member, StvacINV1, regulates cold-induced sweetening of tubers. Molecular Genetics and Genomics. 2011, 286 (2): 109-18
4. Nie B, Singh M, Sullivan N, Singh R P, Xie C and Nie X. Recognition and molecular discrimination of severe and mild PVYO variants of Potato virus Y in potatoes in New Brunswick, Canada. Plant Disease. 2011, 95: 113-119.

with CIP

1. Tian Z D, Liu J, Portal L, Bonierbale M and Xie C H. Mapping of candidate genes associated with late blight resistance in potato and comparison of their location with known quantitative trait loci. Canadian Journal of Plant Science. 2008, 88: 599-610.
2. Li J, L-K Hannele, Tian Z, Liu J, Song B, Landeo J, Portal L, Gastelo M, Frisancho J, Sanchez L, Meijer D, Xie C, Bonierbale M. Conditional QTL underlying resistance to late blight in a diploid potato population. Theoretical and Applied Genetics. 2012, 124:1339–1350
3. Li J, Xie C, Tian Z, Lindqvist-Kreuze H, Bonierbale M, Liu J. SSR and e-PCR Provide a Bridge Between Genetic Map and Genome Sequence of Potato for Marker Developmentin Target QTL Region. American Journal of Potato Research. 2015, 92:312–317

with University of Wisconsin at Madison

1. Cai X K, Spooner D M, and Jansky S H. A test of Taxonomic and biogeographic predictivity: resistance to Potato Virus Y in wild relatives of the cultivated potato. Phytopathology. 2011, 101: 1 074–1080
2. Simon R, Xie C H, Jansky S H, Halterman D, Conner T, Knapp S, Brundage J, Symon D, Spooner D. Wild and cultivated potato (Solanum sect. Petota) escaped and persistent outside of its natural range. Invasive Plant Science and Management. 2010, 3:286-293.
3. Jansky S H, Jin L P, Xie K Y, Xie C H, Spoone r D M. Potato Production and Breeding in China. Potato Research. 2009, 52: 57–65.


Thank you !