Plant Immunity and Disease Control

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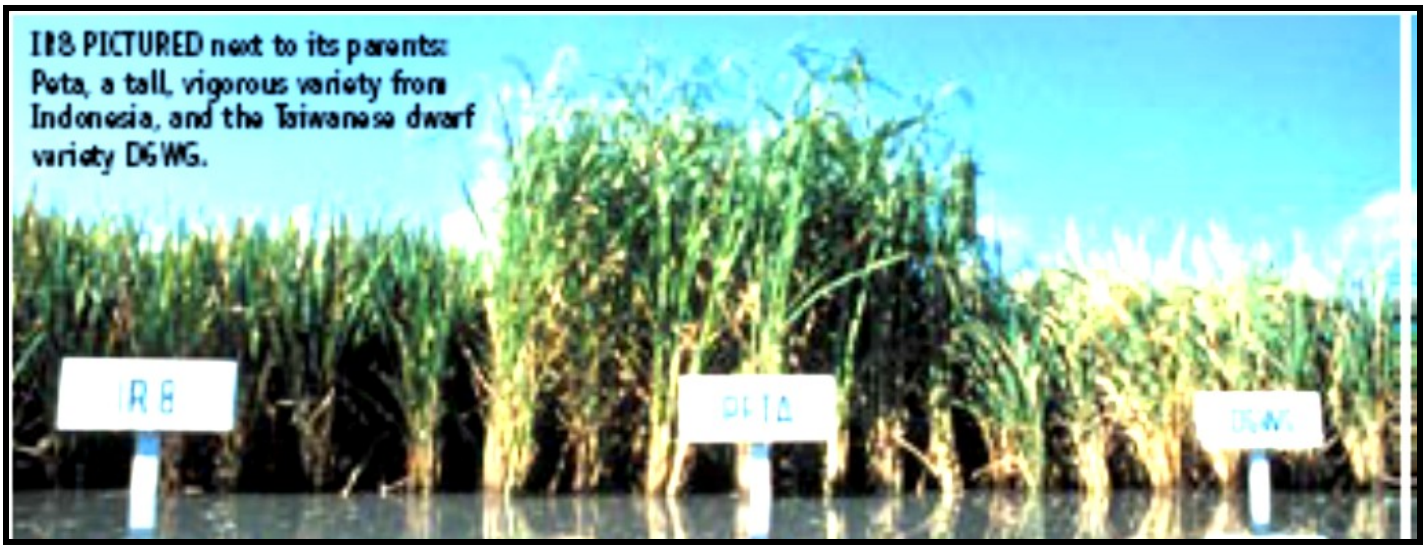
Rice is the Most Important Cereals!

	Million hectare	Million tons
Rice	153	587
Maize	139	600
Wheat	214	578

- Rice is consumed only by human beings.
- Maize and wheat are also used to feed animals and maize has recently be used to produce ethanol.

Khush and Virk 2001. Rice Improvement

Green Revolution and Miracle Rice IR8: One Side of the Coin



IR8

Peta,
A tall and vigorous variety from Indonesia

Dee-geo-woo-gen
低脚烏尖,
a smidwarf variety from China

Doubled the annual rice production in the Philippines and made the Philippines a rice exporter.

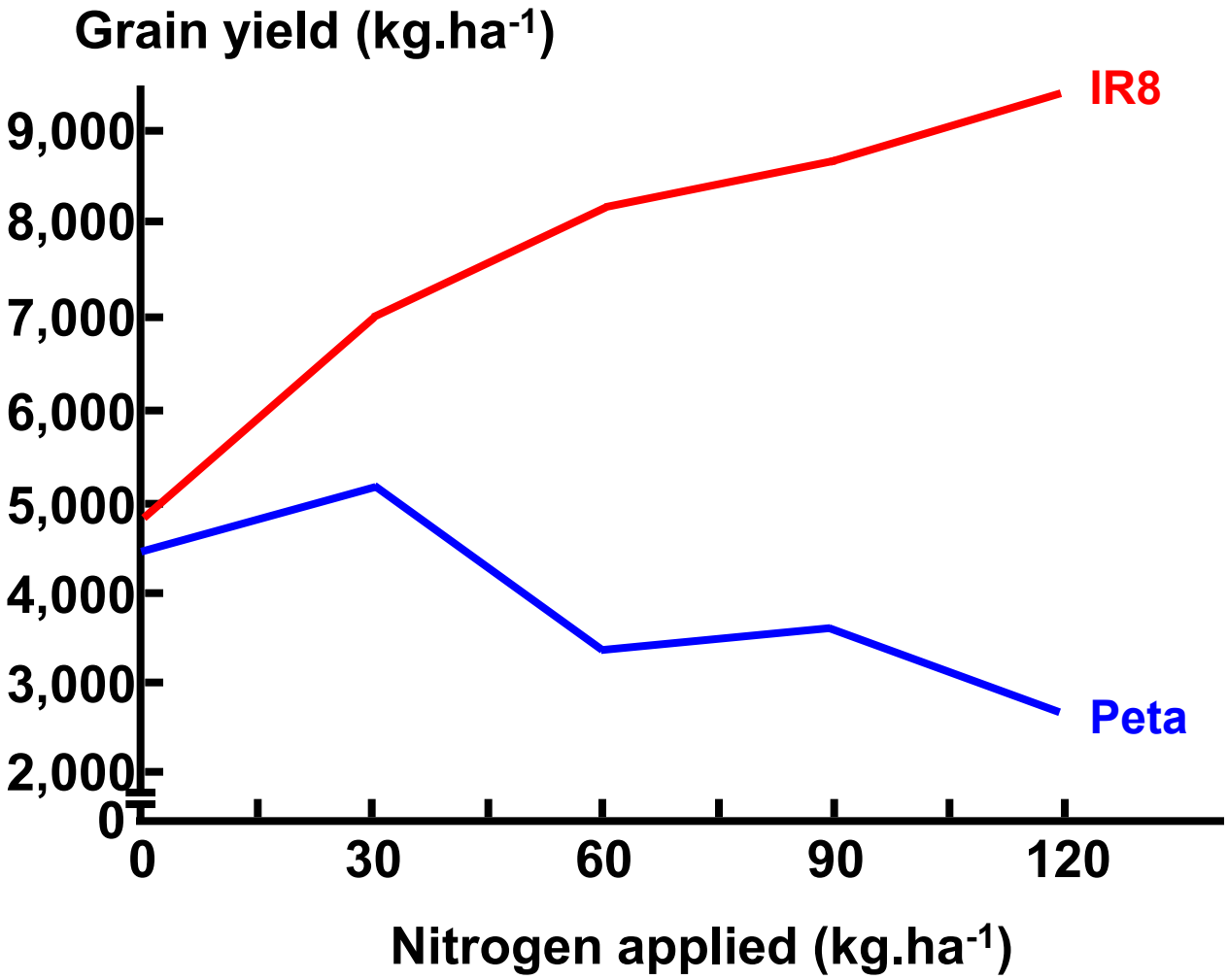
IR8 was widely distributed to many countries in Asia.

"During the last half of 1966 alone, 2,359 Philippine farmers came to IRRI by bus, on bicycle, and on foot, from 48 of the country's 56 provinces, to get seeds."

Rice Today 2006

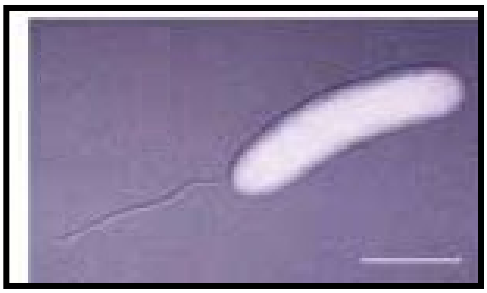
Green Revolution and Miracle Rice IR8:
One Side of the Coin

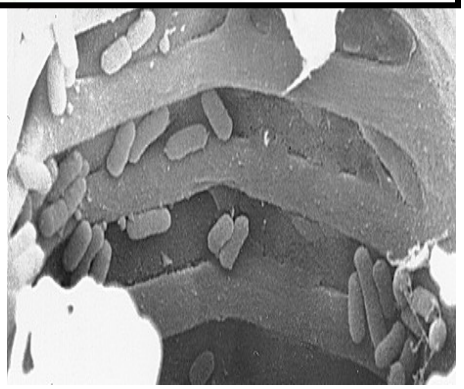
Nitrogen Response of Peta and IR8 During 1966 Dry Season at IRRRI

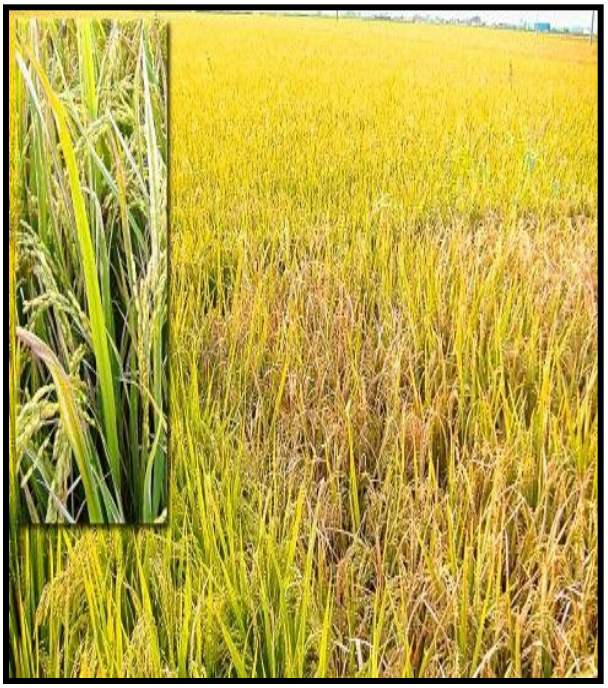


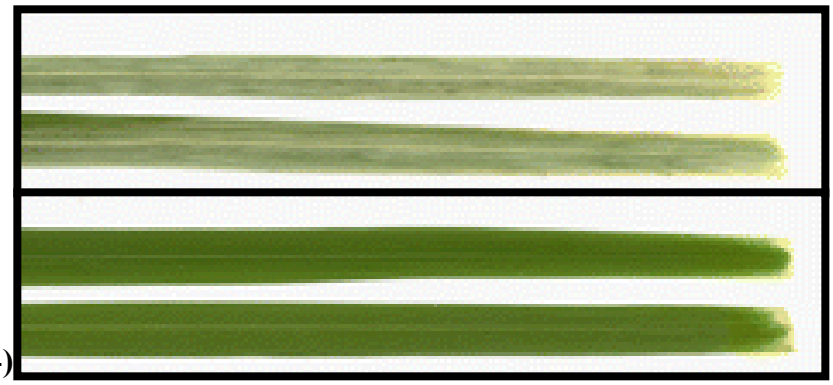
Outbreak of Bacterial Blight Disease of Rice: the Other Side of the Coin

Causal agent: *Xanthomonas oryzae* pv. *oryzae* (*Xoo*)







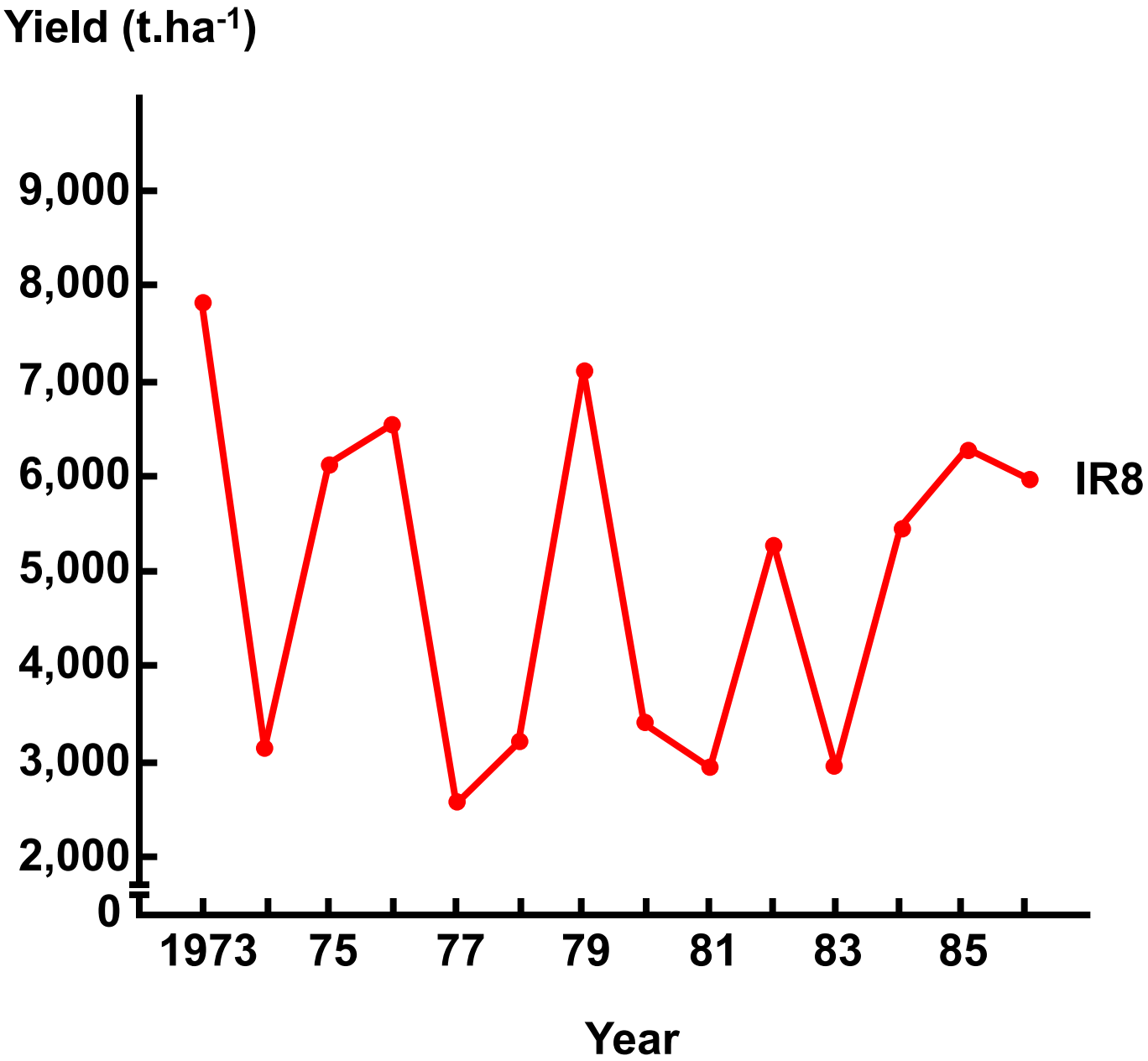


(Molecular Plant Pathology, 7, 303-324)

Xoo Infection

Mew et al Plant Disease 77:5

Yields of IR8 for Dry-Season, Replicated Yield Trials at IRRI



Outbreak of Bacterial Blight of Rice
the Other Side of the Coin

"Bacterial blight has made little harm as far as local varieties had been cultured without any fertilization. But almost all high yielding varieties which Southeast Asian countries adopted are very susceptible to bacterial blight."

"In only ten years, the disease spread throughout the region as the use of the IRRI variety (IR8) became widespread. Farmers lost up to 80 per cent of their harvests."

"It is clear that IRRI varieties are assisting the disease to spread wider."

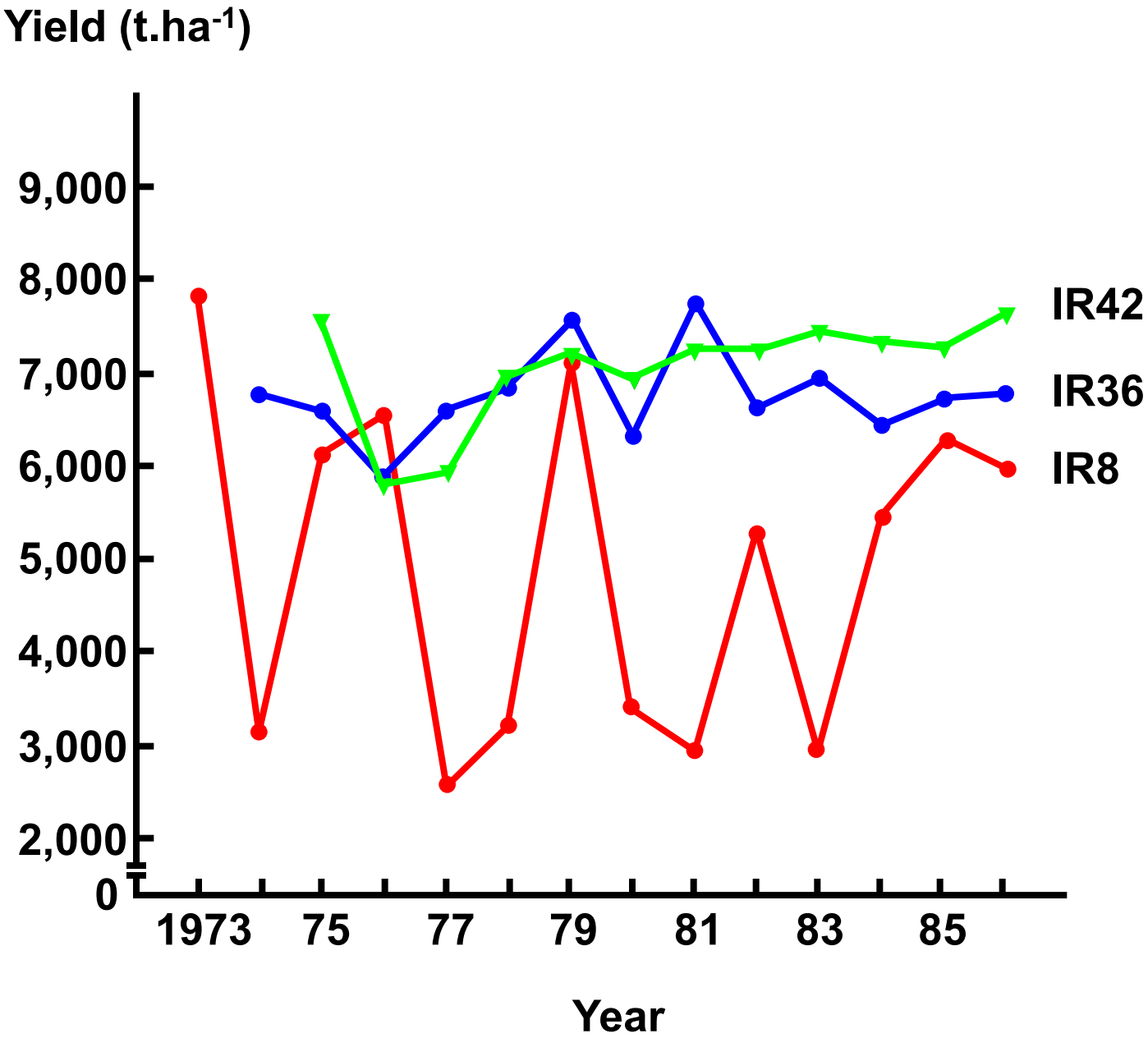
From Bengwayan, MA. "Entry of GMO BB-Rice Stirs Hornet's Nest'
The Philippine Post, October 2000
http://www.biotech-info.net/BB_rice.html
http://en.wikipedia.org/wiki/Green_Revolution

Bacterial Blight Resistance Genes

Gene	Source	Gene Product
Xa1	**Kogyoku**	**NB-LRR**
Xa2	Tetep	
Xa3/Xa26	**Wase Aikoku 3/Minghui63**	**RLK**
Xa4	TKM 6	
xa5	**Aus Boro lines (e.g. DZ192)**	**TFIIA γ subunit**
Xa7	DV85	
xa8	PI231129	
Xa10	Cas209	
Xa11	IR8, IR944	
Xa12	Kogyoku	
xa13	**BJ1 (Aus Boro)**	**Novel**
Xa14	TN1	
xa15	M41 (a mutant of Harebare)	
Xa16	Tetep	
Xa17	Asiminori	
Xa18	IR24, Toyonishiki	
xa19	XM5	
xa20	XM6	
Xa21	***Oryza longistaminata***	**RLK**
Xa22	Zhachanglong	
Xa23	*Oryza rufipogon*	
xa24(t)	DV86, DV85, Aus 295	
Xa25(a)	HX-3 (a mutant of Minghui63)	
Xa27	***Oryza minute***	**Novel**
xa28	Lota Sail	
Xa29(t)	*Oryza officinalis*	

Nino-Liu et al. Molecular Plant Pathology, 2006

Yields of IR8, IR36, and IR42 for Dry-Season, Replicated Yield Trials at IRRI



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Nino-Liu et al. Molecular Plant Pathology, 2006

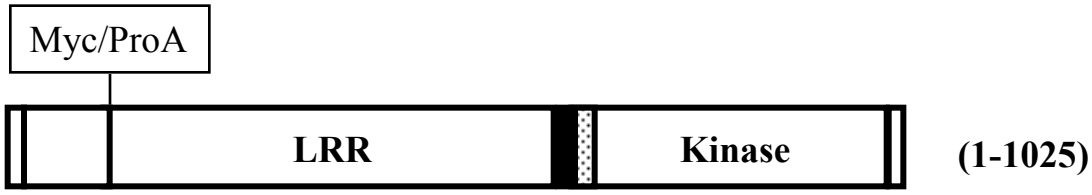
A Receptor Kinase–Like Protein Encoded by the Rice Disease Resistance Gene, *Xa21*

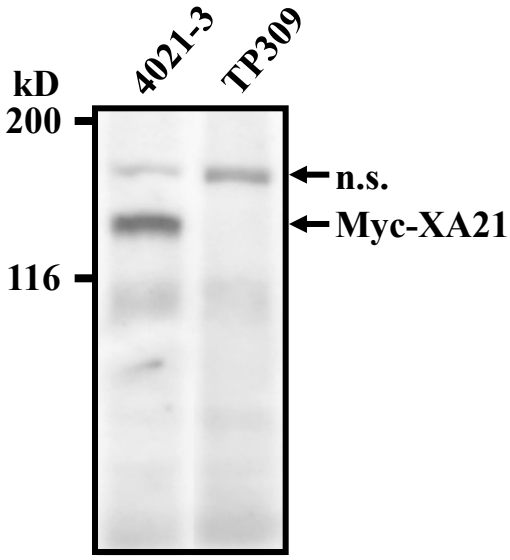
Wen-Yuan Song,* Guo-Liang Wang,* Li-Li Chen, Han-Suk Kim, Li-Ya Pi, Tom Holsten, J. Gardner, Bei Wang,† Wen-Xue Zhai, Li-Huang Zhu, Claude Fauquet, Pamela Ronald‡

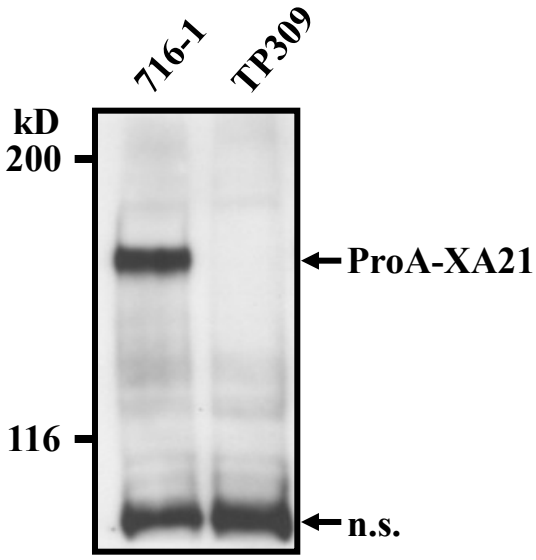
The rice *Xa21* gene, which confers resistance to *Xanthomonas oryzae* pv. *oryzae* race 6, was isolated by positional cloning. Fifty transgenic rice plants carrying the cloned *Xa21* gene display high levels of resistance to the pathogen. The sequence of the predicted protein, which carries both a leucine-rich repeat motif and a serine-threonine kinase–like domain, suggests a role in cell surface recognition of a pathogen ligand and subsequent activation of an intracellular defense response. Characterization of *Xa21* should facilitate understanding of plant disease resistance and lead to engineered resistance in rice.

Science 1995

Immuno-detection of the XA21 Protein

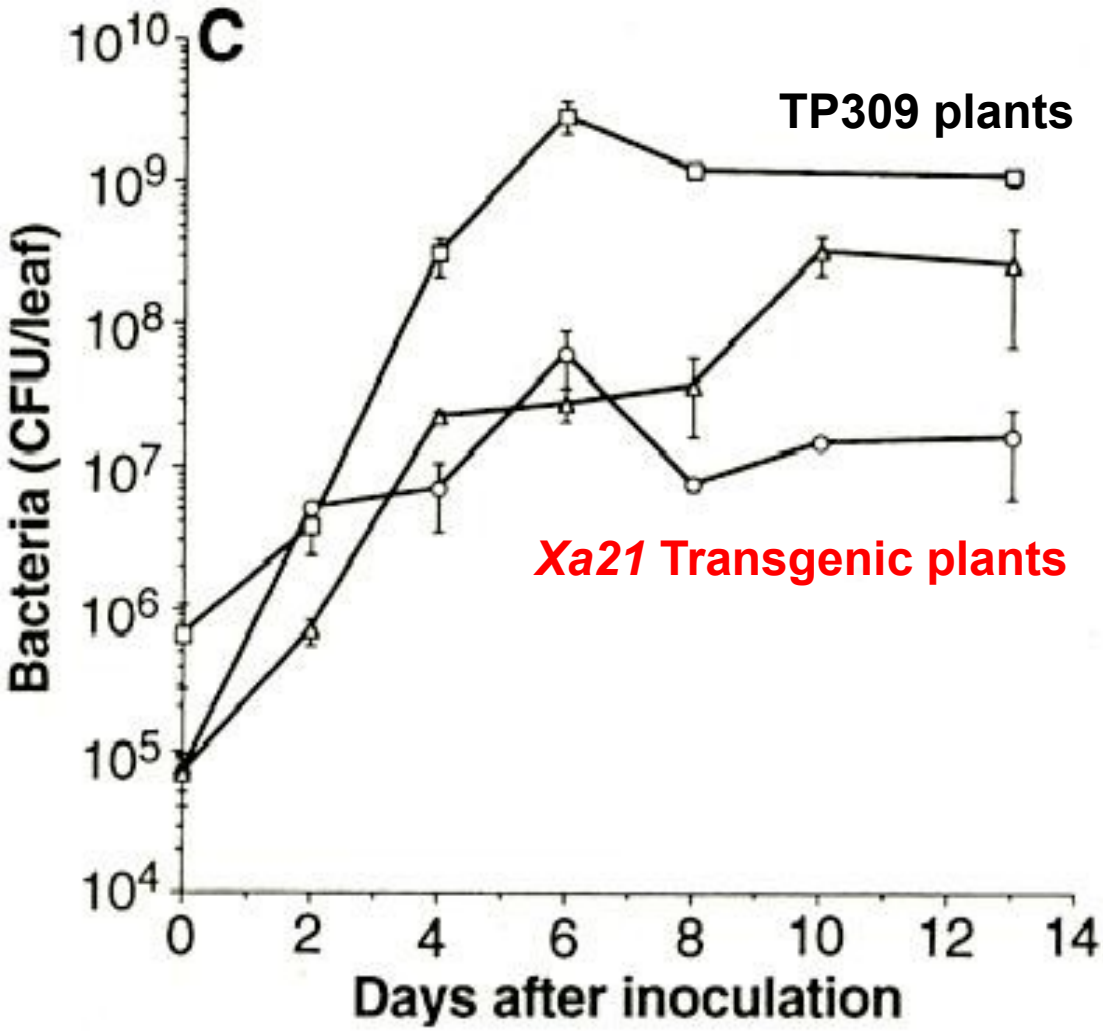




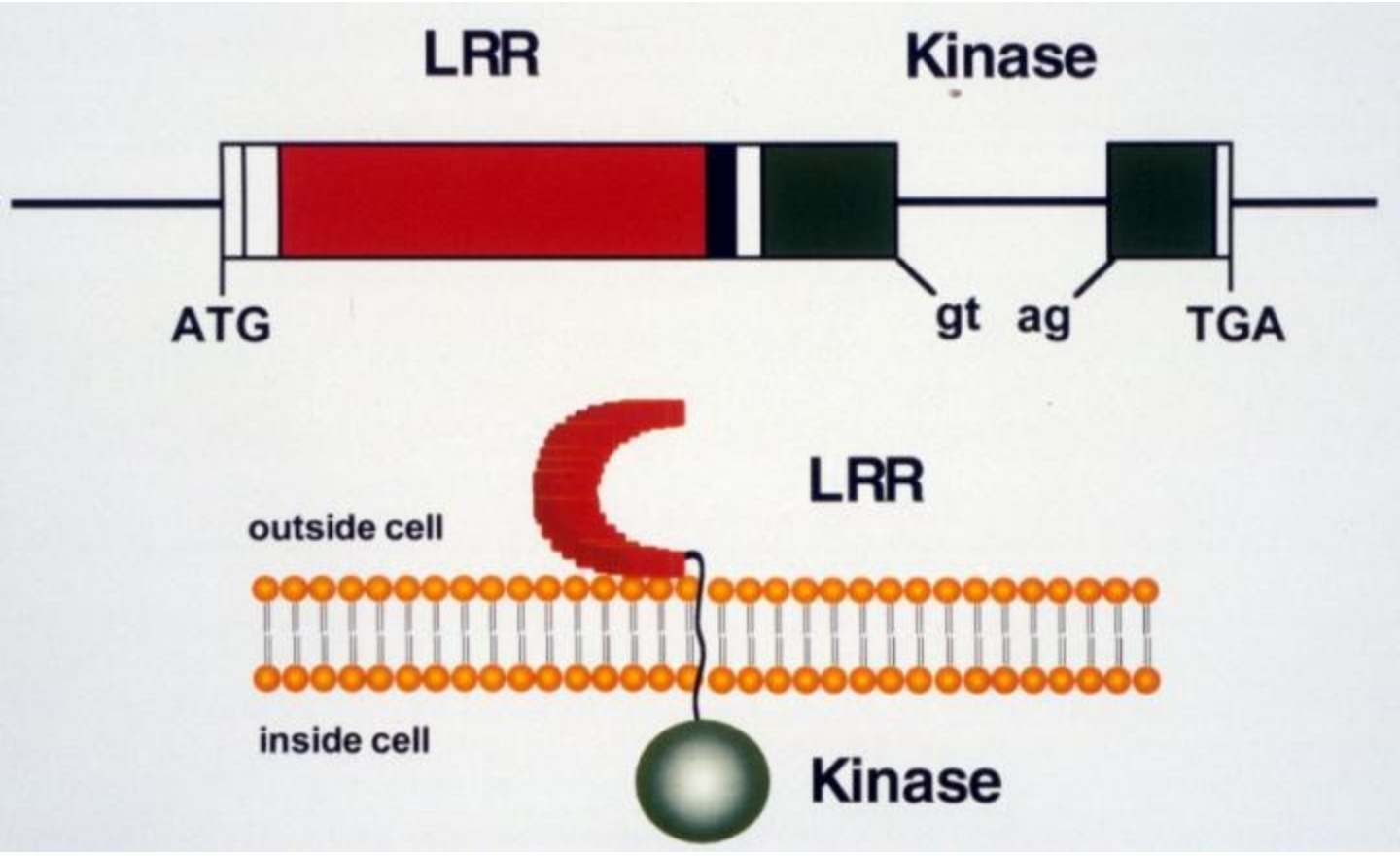


cm
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19
No 36

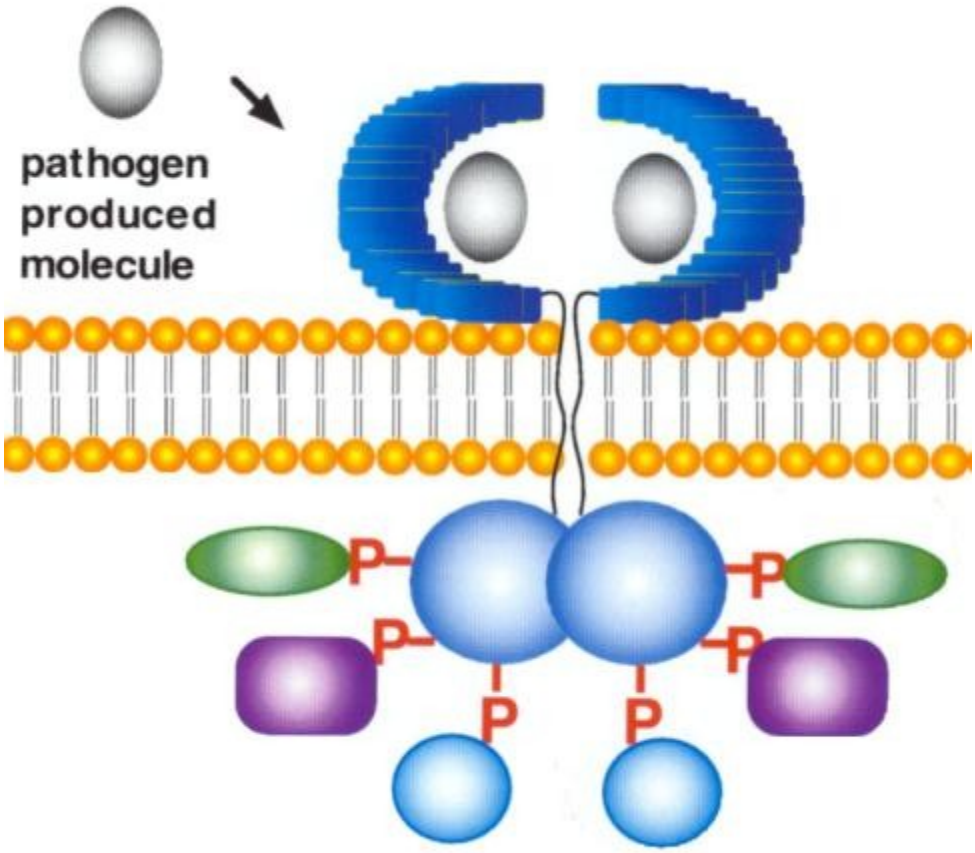
Growth Curve Analysis of Transgenic Plants



Xa21 Encodes a Receptor Kinase-like Protein

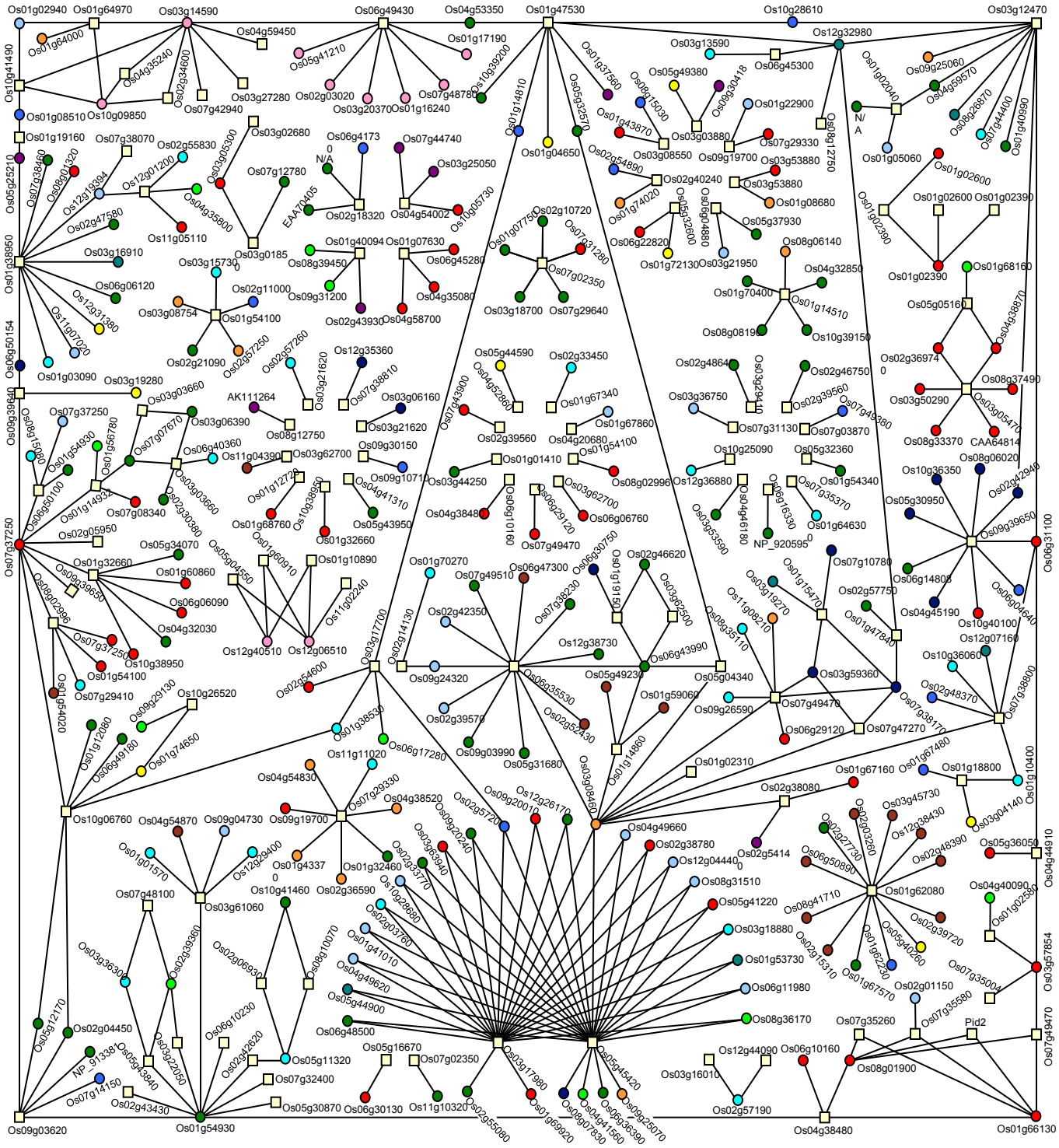


Model of XA21-mediated Resistance



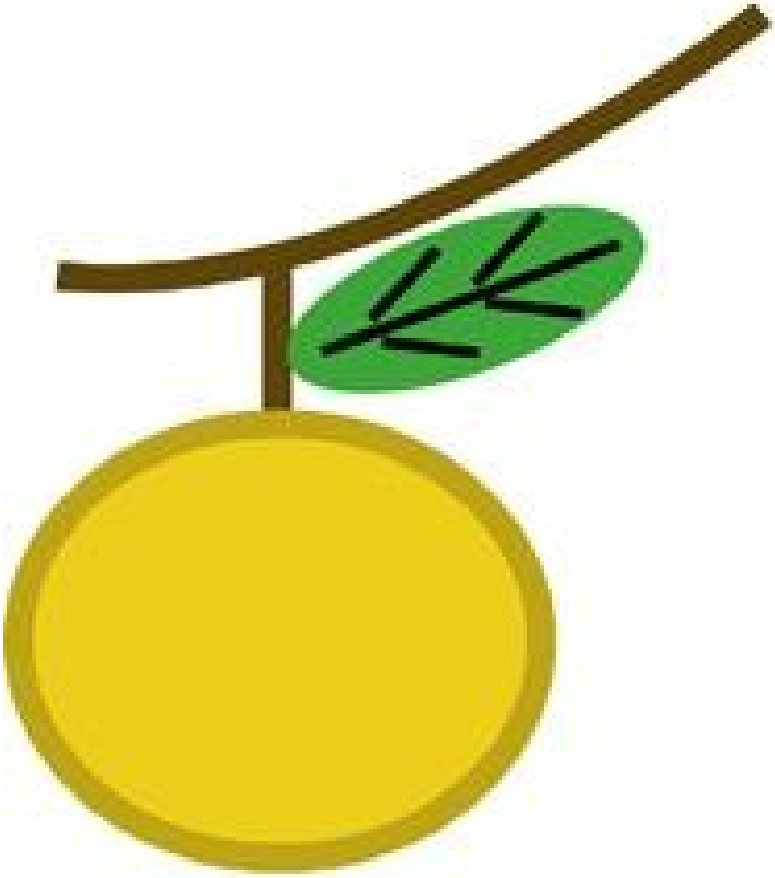
Resistance Response

A Rice Kinase Interaction Network



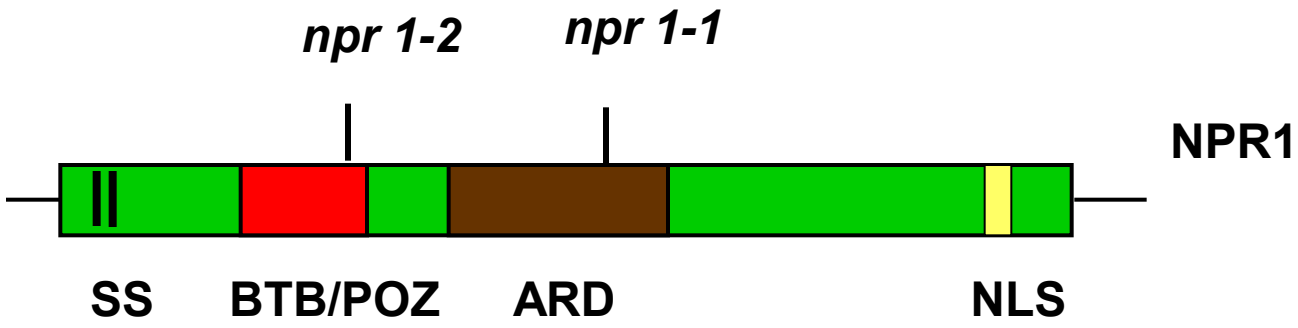
□ **Bait kinase** ○ **Interacting proteins (Prey)**

Overexpression of *NPR1* Confers Enhanced Resistance to Citrus Canker?



Citrus

The NPR1 Protein



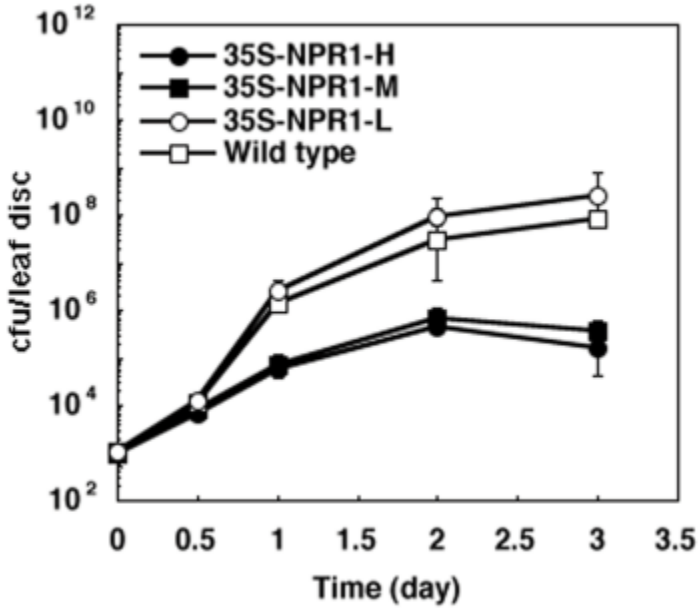
SS: Possible phosphorylation sites (serines)

BTB/POZ: BTB/POZ domain; protein-protein interaction

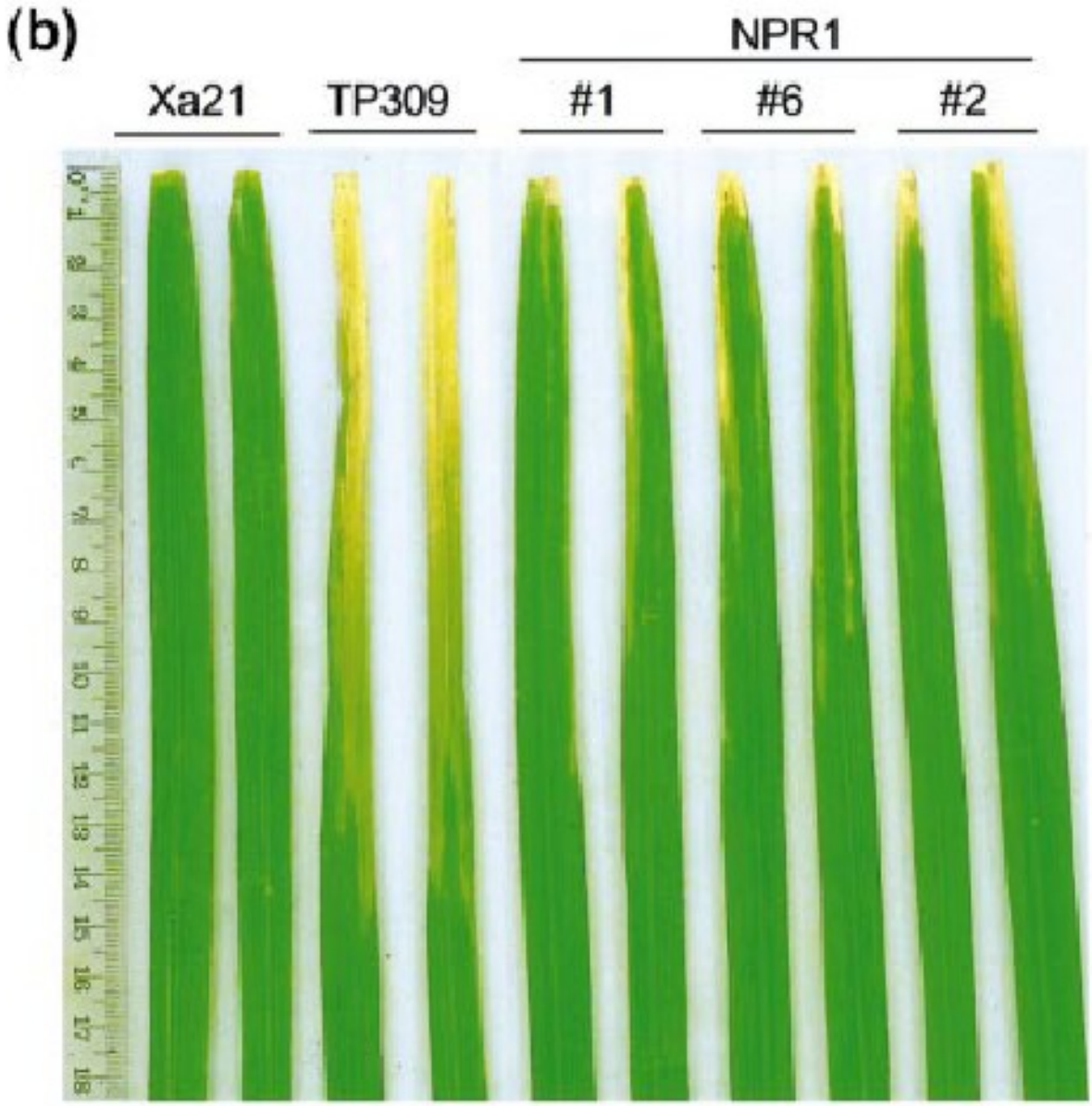
ARD: Ankyrin-repeat domain; protein-protein interaction

Overexpression of *NPR1* Results in Enhanced Resistance to P. *s.* pv *maculicola* ES4326

WT NPR1-L NPR1-M NPR1-H



Overexpression of *NPR1* Results in Enhanced Resistance to *Xoo* in Rice



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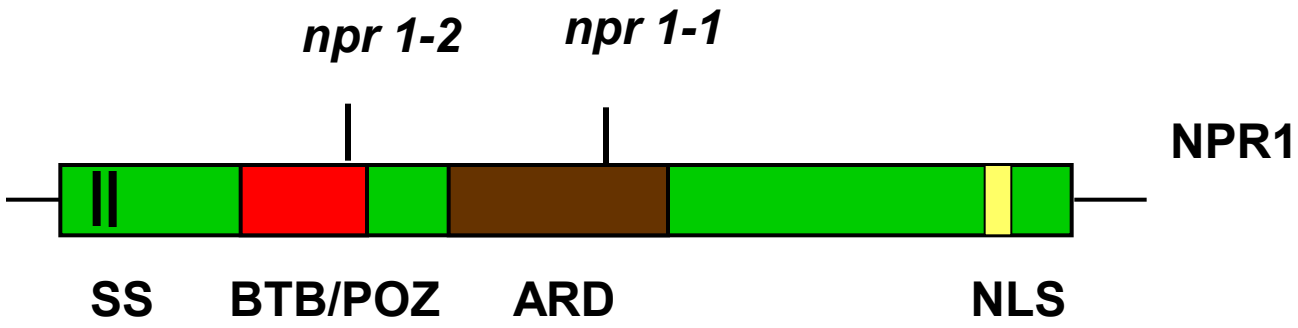

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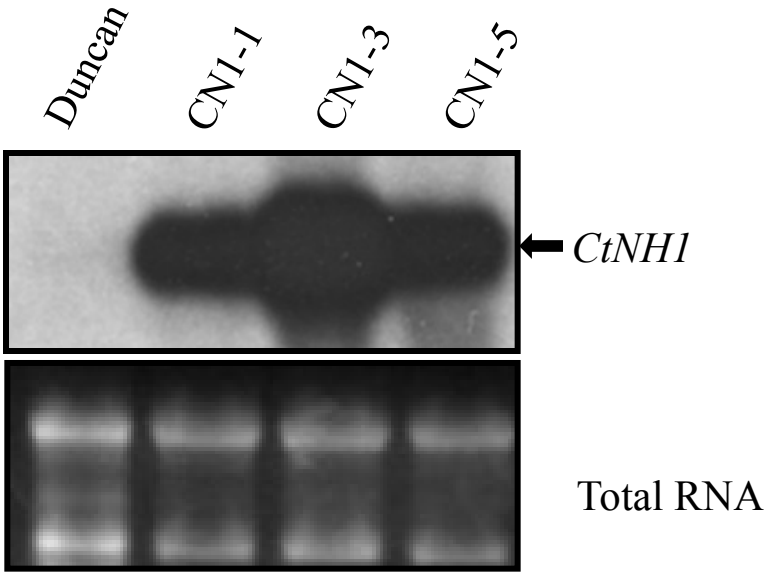
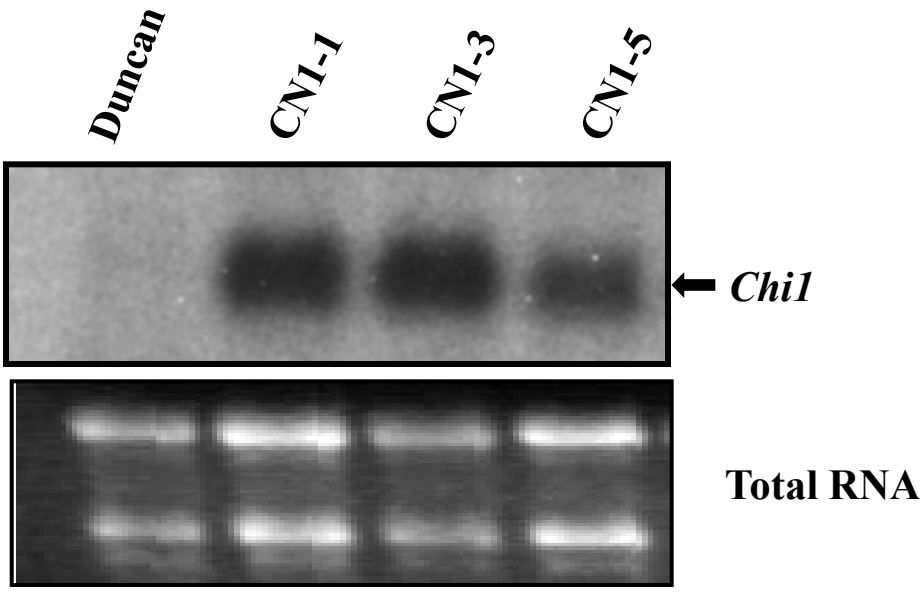
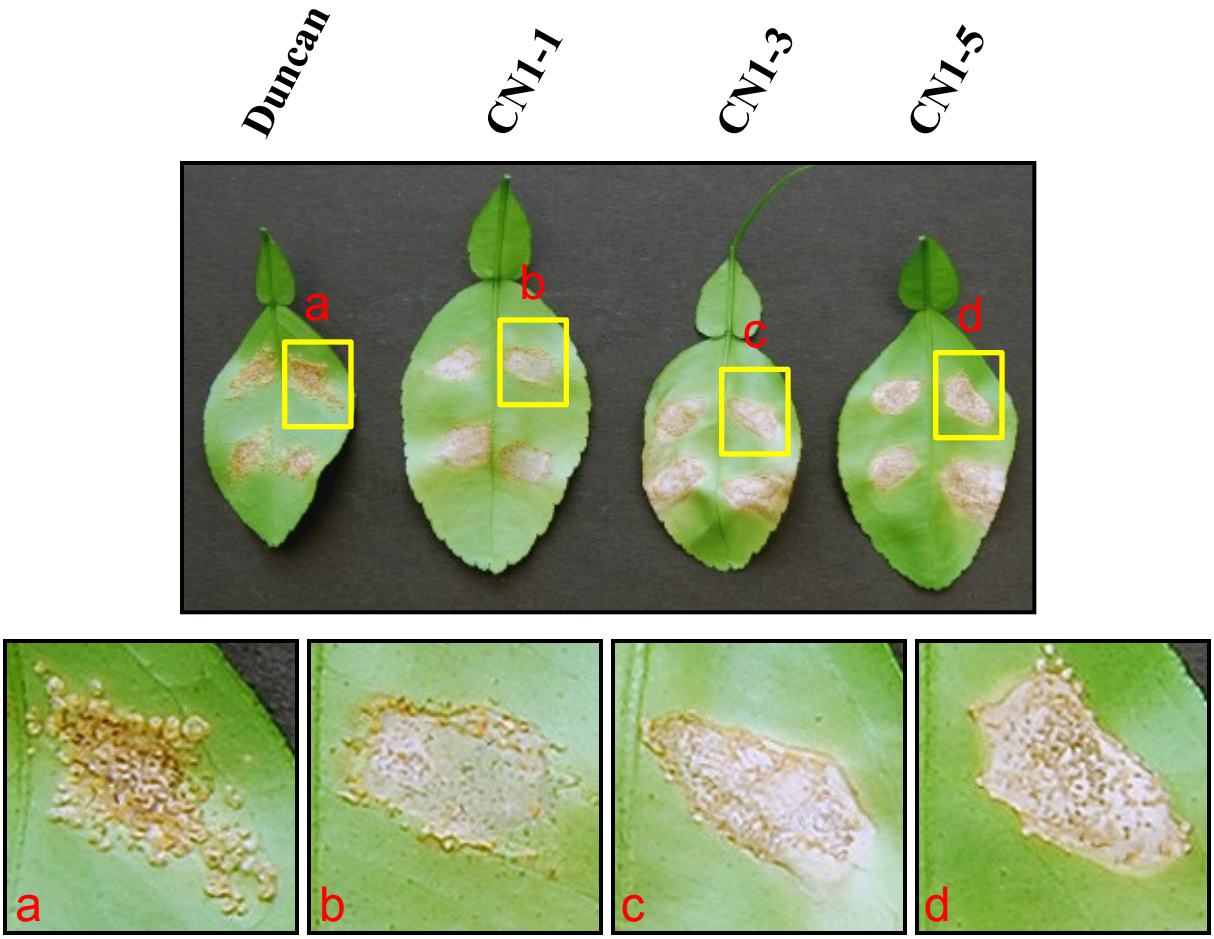
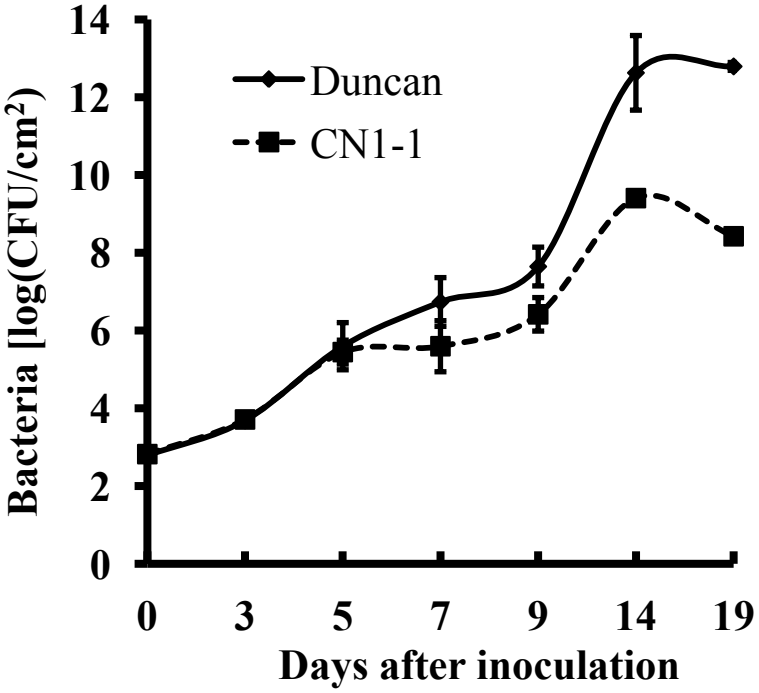

Duncan
CN1-1
CN1-3
CN1-5
CtNH1
Total RNA


Duncan
CN1-1
CN1-3
CN1-5
Chi1
Total RNA


Duncan
CN1-1
CN1-3
CN1-5
a
b
c
d
a
b
c
d


Duncan
CN1-1
Bacteria [log(CFU/cm²)]
0
2
4
6
8
10
12
14
0
3
5
7
9
14
19
Days after inoculation

Acknowledgements

- Xiuhua Chen
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- Li-Ya Pi

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