

Current State of *Phytophthora* Resistance: *Rps* and QTL

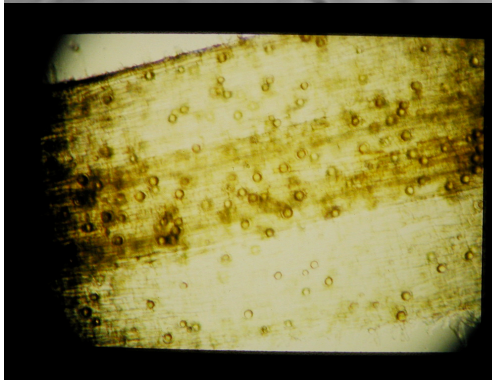
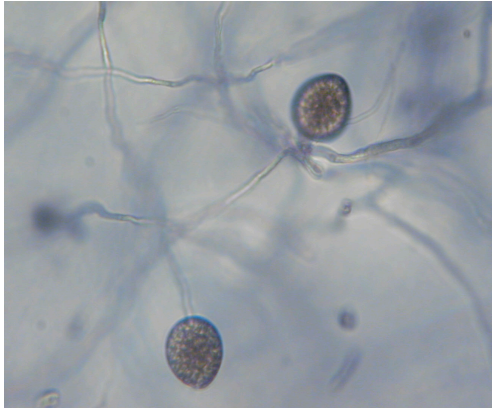
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Department of Plant Pathology



Phytophthora sojae

- Diseases
- *Rps* genes
- Partial resistance
 - QTL



Symptoms of Phytophthora



Management of *P. sojae*

- Host resistance
 - *Rps* genes
 - Partial resistance
- Cultural practices
- Fungicide seed treatments
- Crop rotation



Specific Resistance to *P. soiae*



Hypocotyl Inoculation test



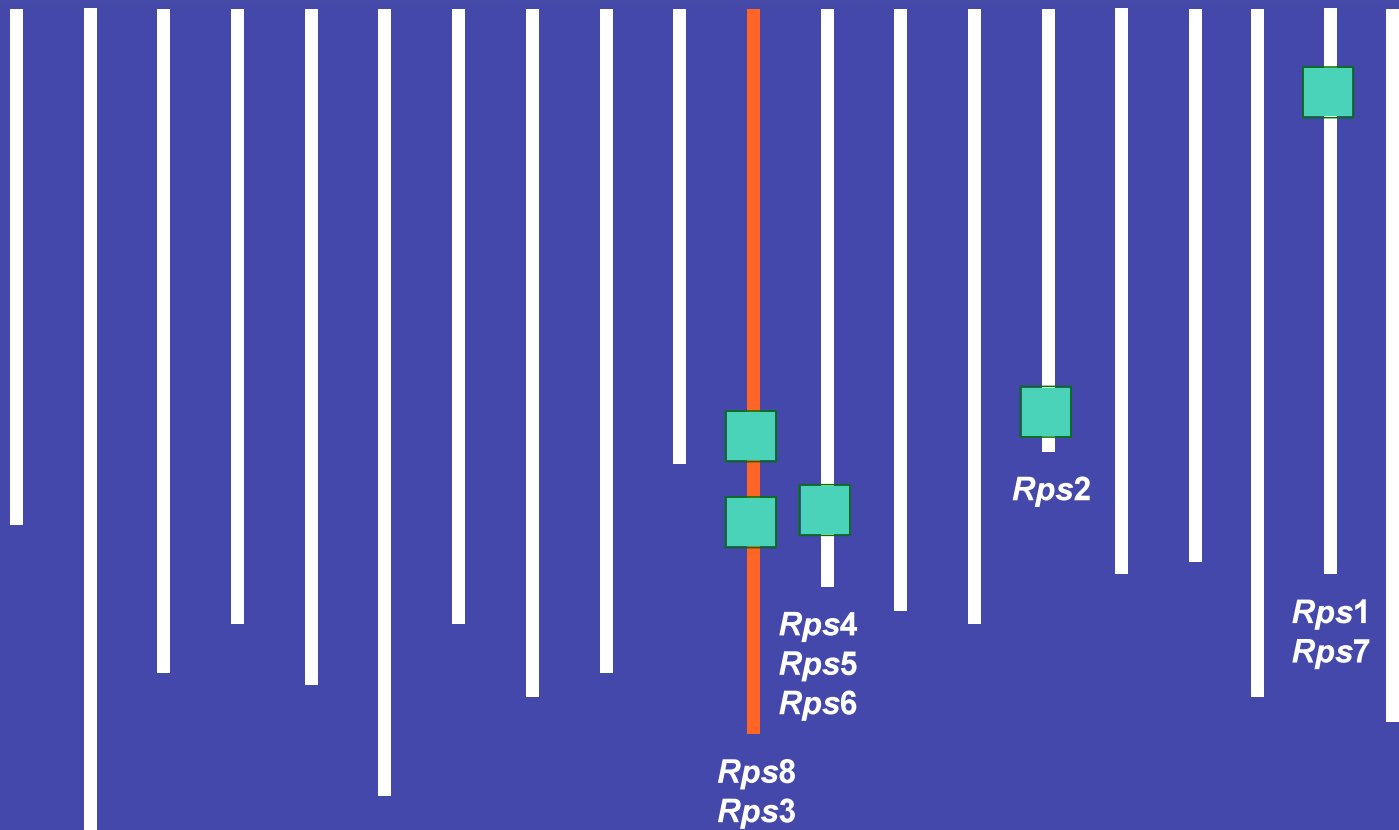
Rps genes

- *Rps1a*, *Rps1c*, *Rps1k*, *Rps3a*, *Rps6*
- 100% or 0% protection
- Hypocotyl Inoculation Test
- Races/pathotypes

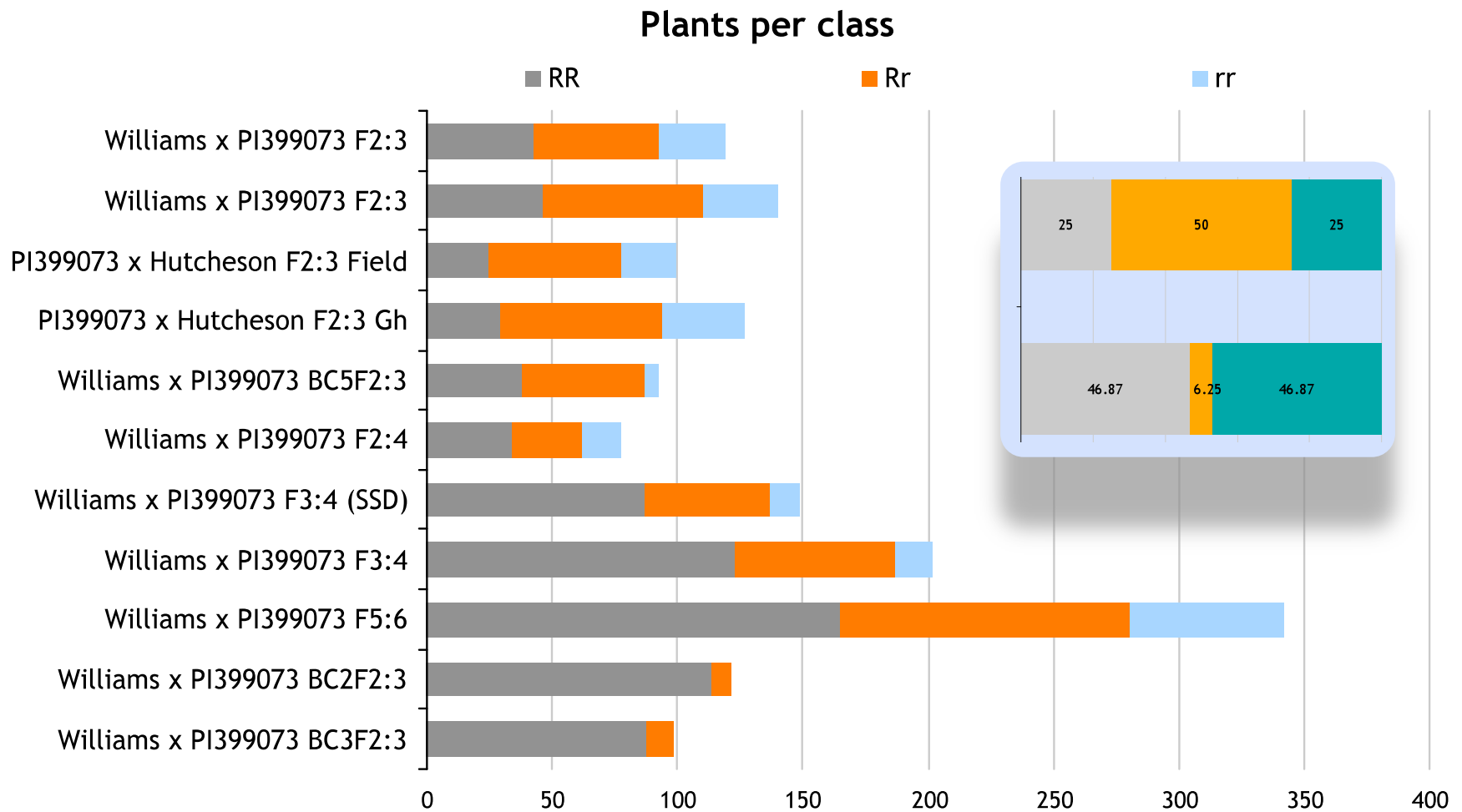
Race	Susceptible
1	7
4	1a, 1c, 7
7	1a, 3a, 6, 7
25	1a, 1b, 1c, 1k

Resistance to *Phytophthora sojae* Genes (*Rps*)

5 8 11 14 4 6 1 2 17 15 13 18 12 20 16 9 19 7 3 10
A1 A2 B1 B2 C1 C2 D1a D1b D2 E F G H I J K L M N O

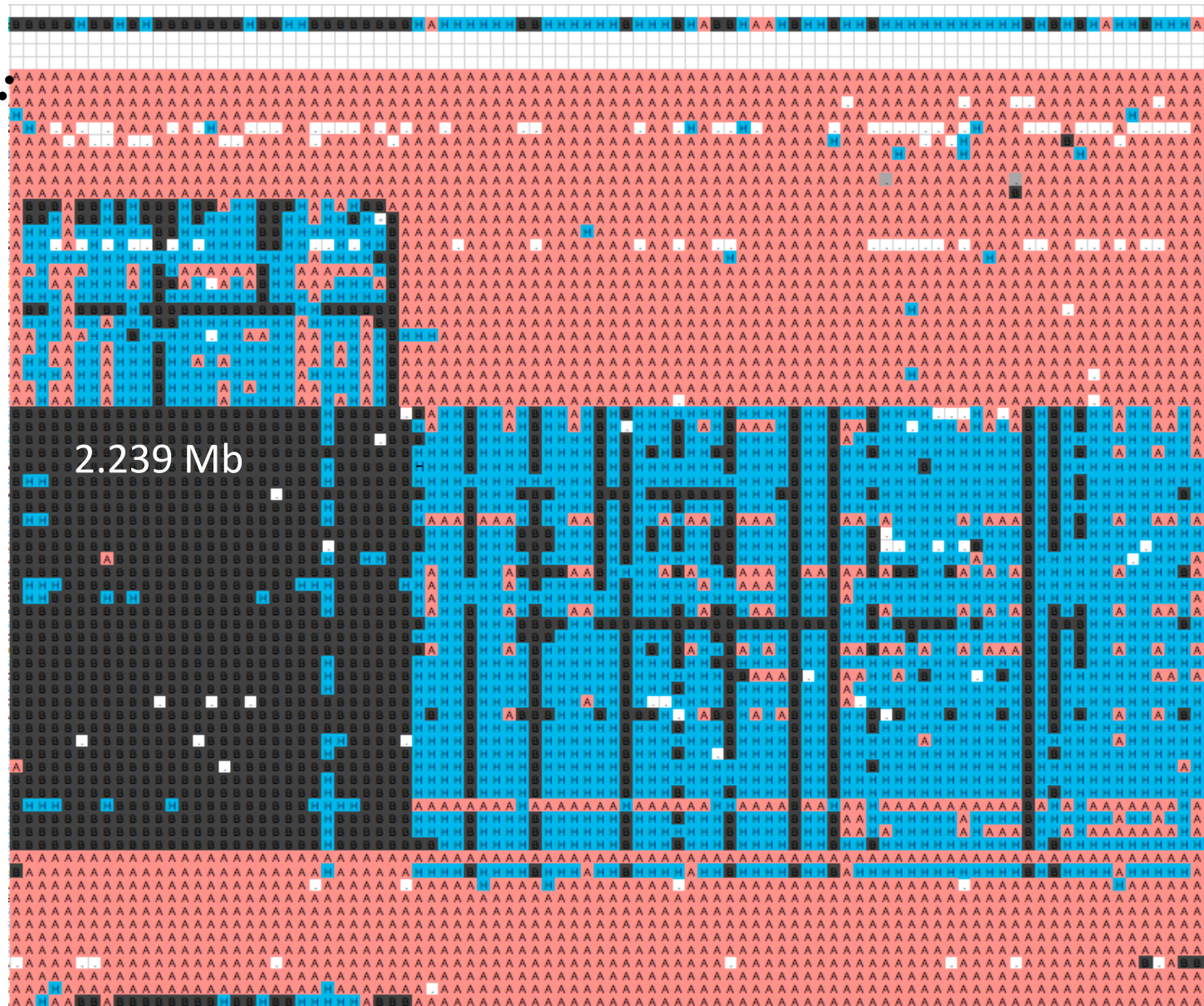


Rps8 Populations Exhibit Segregation Distortion



Williams x PI 399073 BC₄ F_{2:3}

RACE 25



Williams x PI 399073 BC₄ F_{4:5}



RACE 25



RACE 17



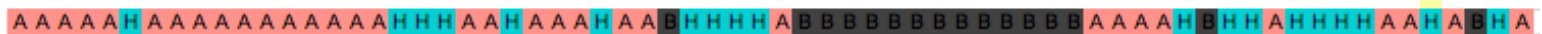
RACE 1



RACE 4

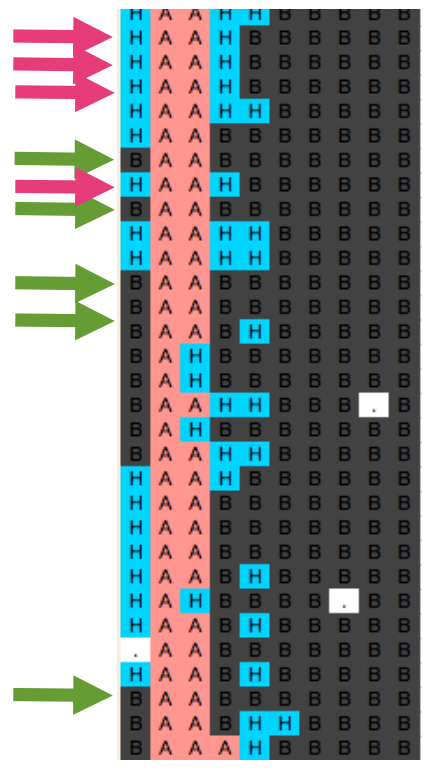


RACE 7



Williams x PI 399073 F_{5:6}

RACE 1	B A A B B B B B B
RACE 17	H H B A H A A A A A
RACE 25	B A A B B B B B B
RACE 2	H A A H B B H B B B
RACE 4	B H H B B B B H B B
RACE 7	H B B A A H A A A A
Z30-2	B B H H A A A A A A
8ONLY	A A A A A A A H A



Rps Genes Predicted in PI 408211B

Gordon *et al.*, 2007

Segregation of Resistance to OH17 (vir1b, 1d, 2, 3a, 3b, 3c, 4, 5, 6 and 7) and OH25 (vir1a, 1b, 1c, 1k and 7) in 'Williams' (*rpsrps*) x PI 408211B(*Rps?Rps?*) $F_{2:3}$

race	R	H	S	ratio	X ²	P-value
OH17	36	32	17	3:1	1.13	0.29
OH25	33	33	0	63:1	1.05	0.46

Segregation of Resistance to OH17 and OH25 in 'Williams' x PI 408211B $F_{2:4}$

race	R	H	S	ratio	X ²	P-value
OH17	17	50	23	3:1	0.02	0.90
OH25	39	46	1	63:1	0.09	0.77

Conclusion: PI 408211B has one gene conferring resistance to OH17 and three genes conferring resistance to OH25

Phenotyping Result

The response to *P. sojae* isolate OH17 (vir 1b, 1d, 2, 3a, 3b, 3c, 4, 5, 6, and 7) in different mapping population

Mapping Population	R	H	S	Expectative ratio	χ^2	P-value
'Williams' x PI 408211B F _{2:4}	25	33	24	1:2:1	3.260	0.196
'Williams' x PI 408211B F _{4:5}	41	8	30	7:2:7	2.157	0.340
BC _{4:7} 'Stressland' X PI 408211B	0	0	352	31:1:31	360	<0.001

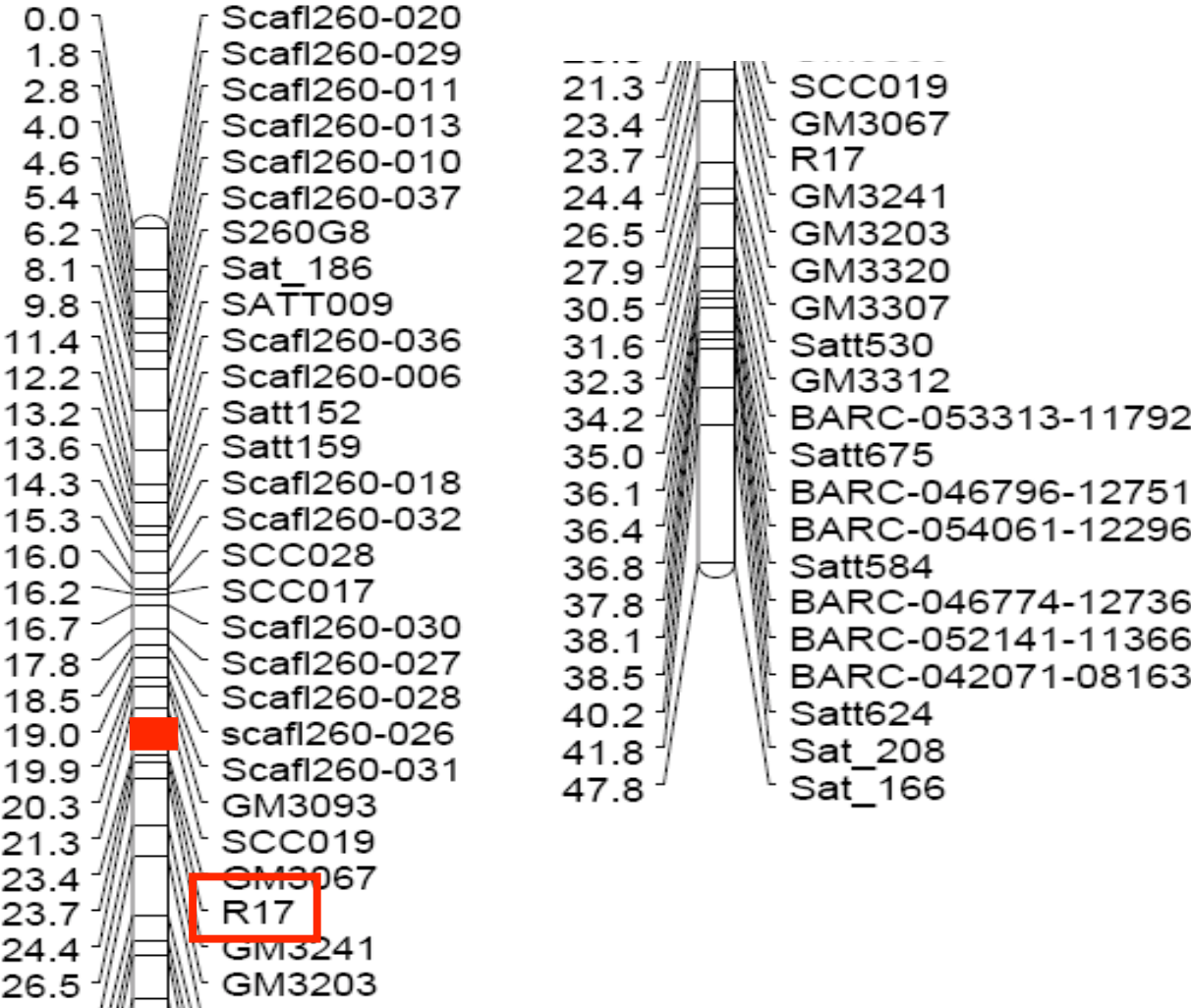
Fine Mapping Resistance to OH17

GM3067

**0.3cM to the north
of the resistance to
OH17**

GM3241

**0.7cM to the south
of the resistance to
OH17**



Mapping resistance to *P. sojae* isolate OH25

P. sojae isolate OH25 (vir 1a, 1b, 1c, 1k, and 7)

Mapping Population	R	H	S	Expectative ratio	X ²	P-value
'Williams' x PI 408211B F _{2:4}	72	11	0	63:1	1.32	0.251
'Williams' x PI 408211B F _{4:5}	34	20	25			
BC _{4:7} 'Stressland' X PI 408211B	227	119	7			

Introgression Detected by SNP Analysis

10 lines homozygous resistant to *P. sojae* isolate OH25

Two each from 5 different BC_{4:3} family

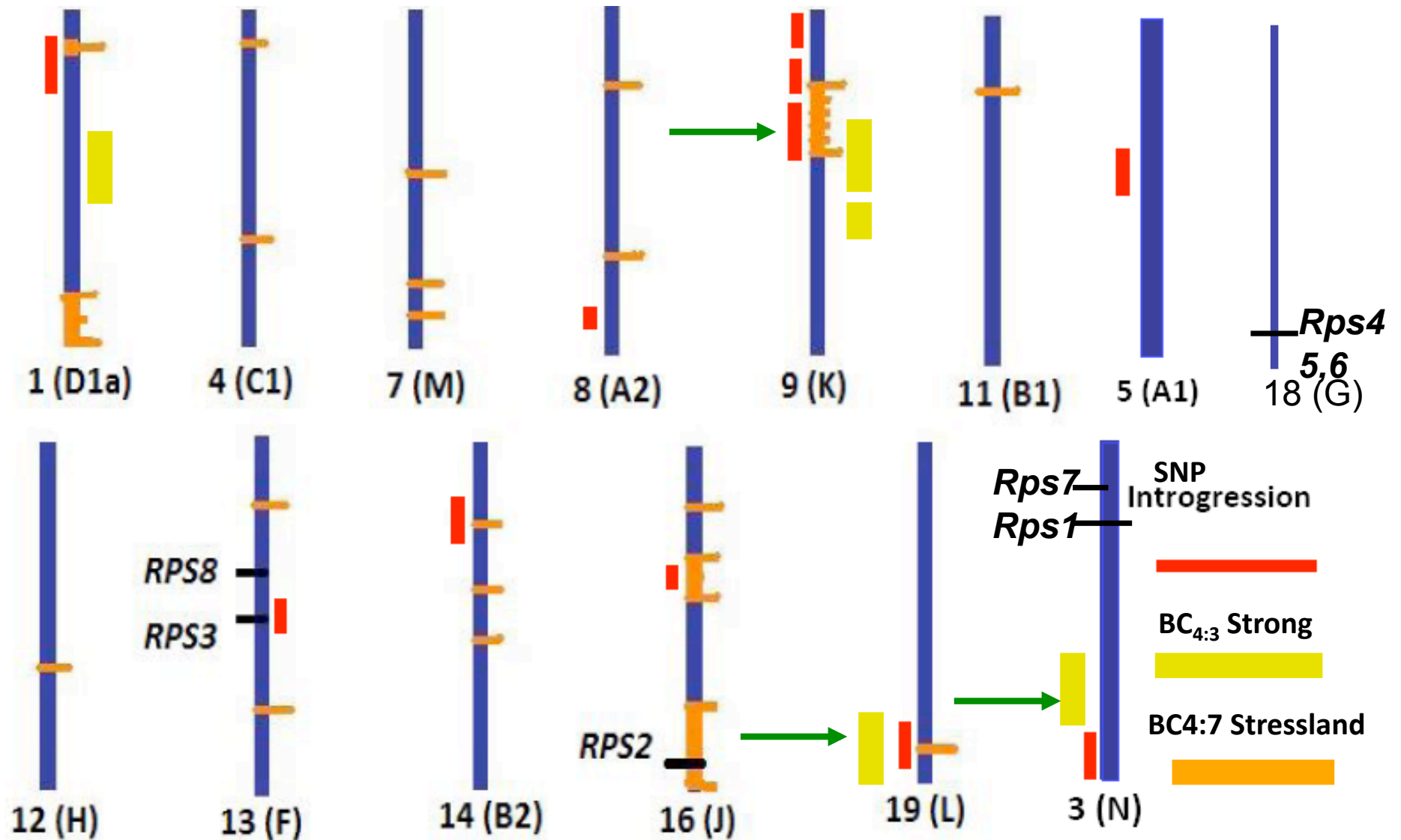
Among 880 SNP markers, 551 markers were polymorphic

57 linked to PI408211B introgression across 9 chromosomes

The response of 10 RILs to OH25 (vir1a, 1b, 1d, 1k, and 7) and OH1 (vir7)

	307	820	1017	1110	1119	1214	1217	1708	1718	1906
OH25	0/14	0/15	0/15	0/14	0/13	0/15	0/15	0/15	0/15	0/15
OH1	5/8	4/10	4/10	6/9	1/10	1/10	6/9	6/10	2/10	7/10

Mapping Resistance to *P. sojae* Isolate OH25



QTL for *P. sojae*

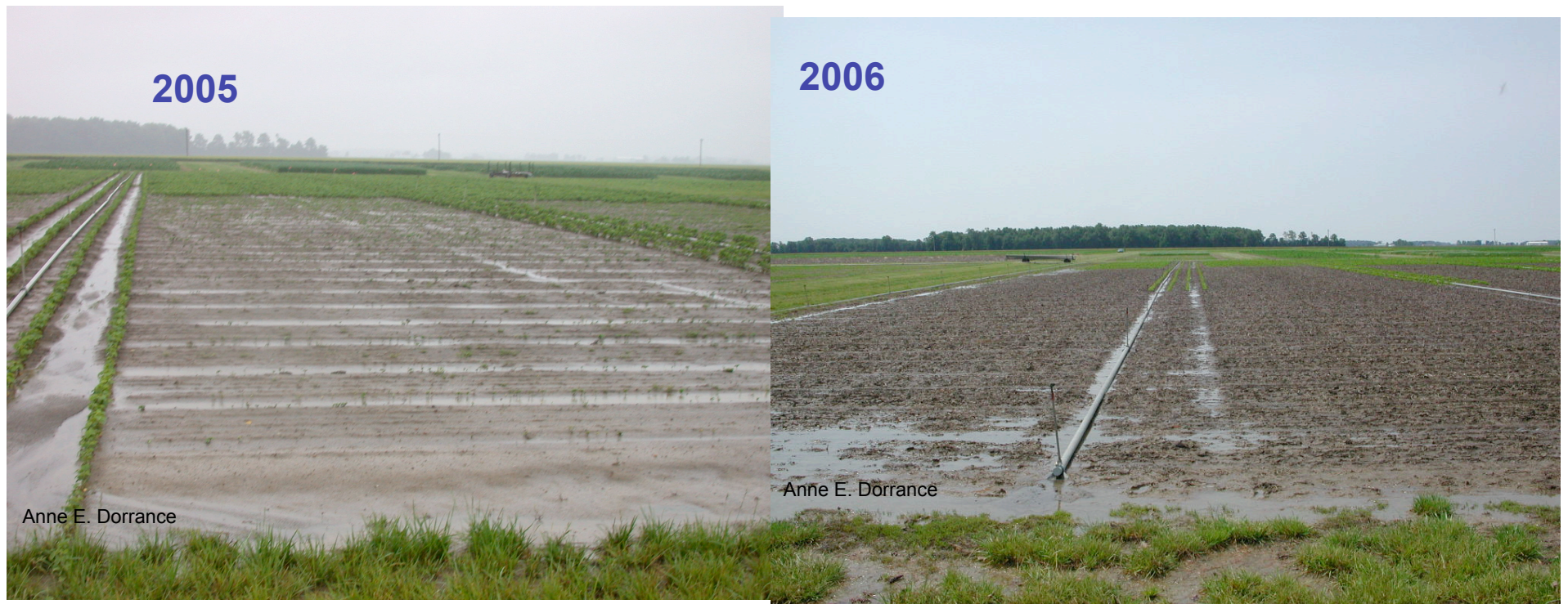


Partial resistance
Non-race specific

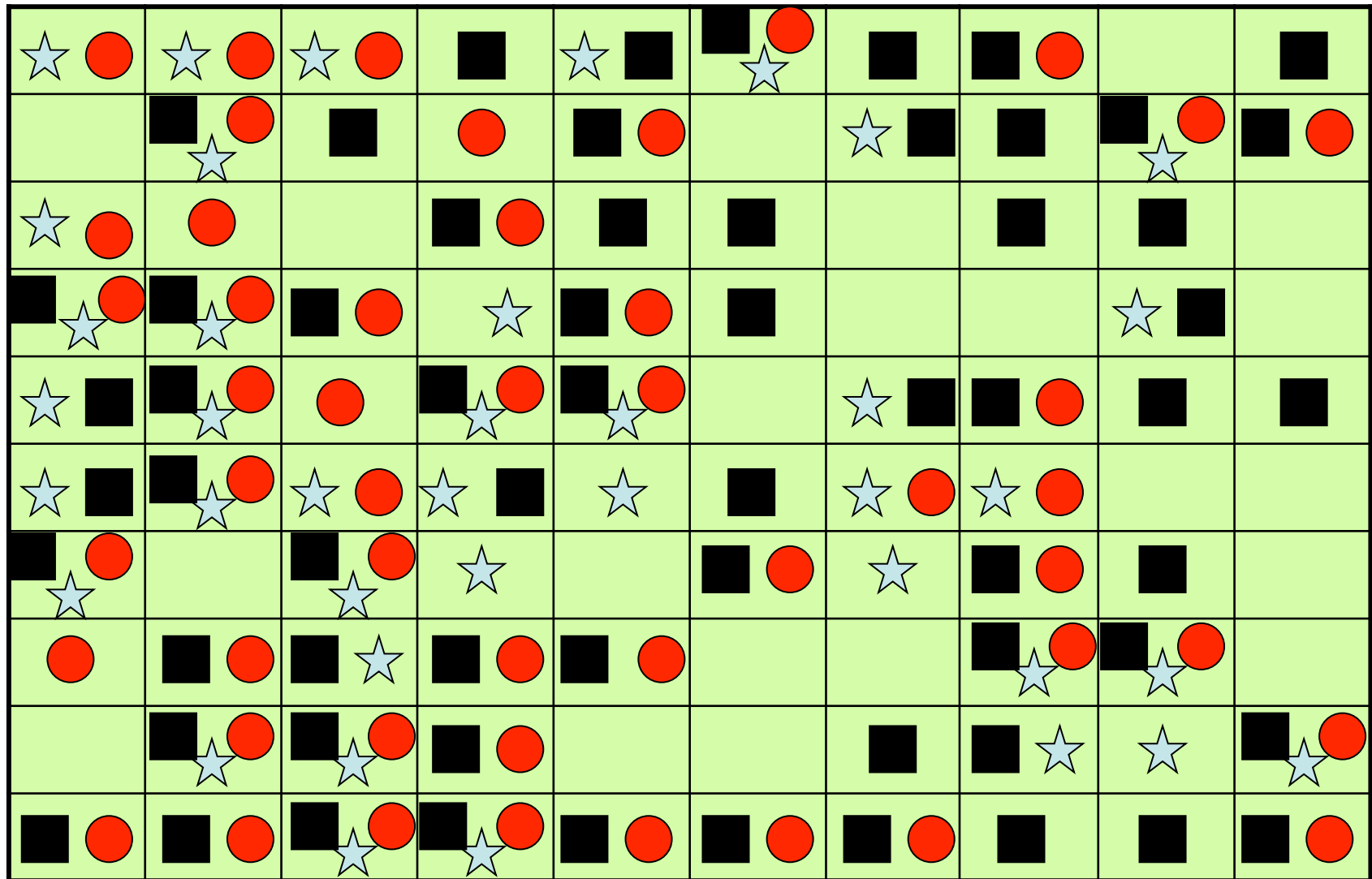
Conrad	13 (F) 21.4-35% 2 (D1b) 10.6 to 20.7%	Tray test Burnham et al., 2000
Conrad	16 (J) – 13.5 to 21.5% Field	Weng et al., 2007
V71-370	16 (J), I, G Tray	Tucker et al., 2010
Conrad	12, 13 (15.7), 13(25), 14, 17, 19	Wang et al., submitted
398297, 414178 407861A, 427105B 408105A, 416783 <i>In progress</i>		Dorrance Mian Shannon, Nguyen, Vong

Field Study

- Fields were irrigated with 2 to 3” of water



Intensive Soil Sampling *P. sojae*



★ =Rps3a

● =Rps1c

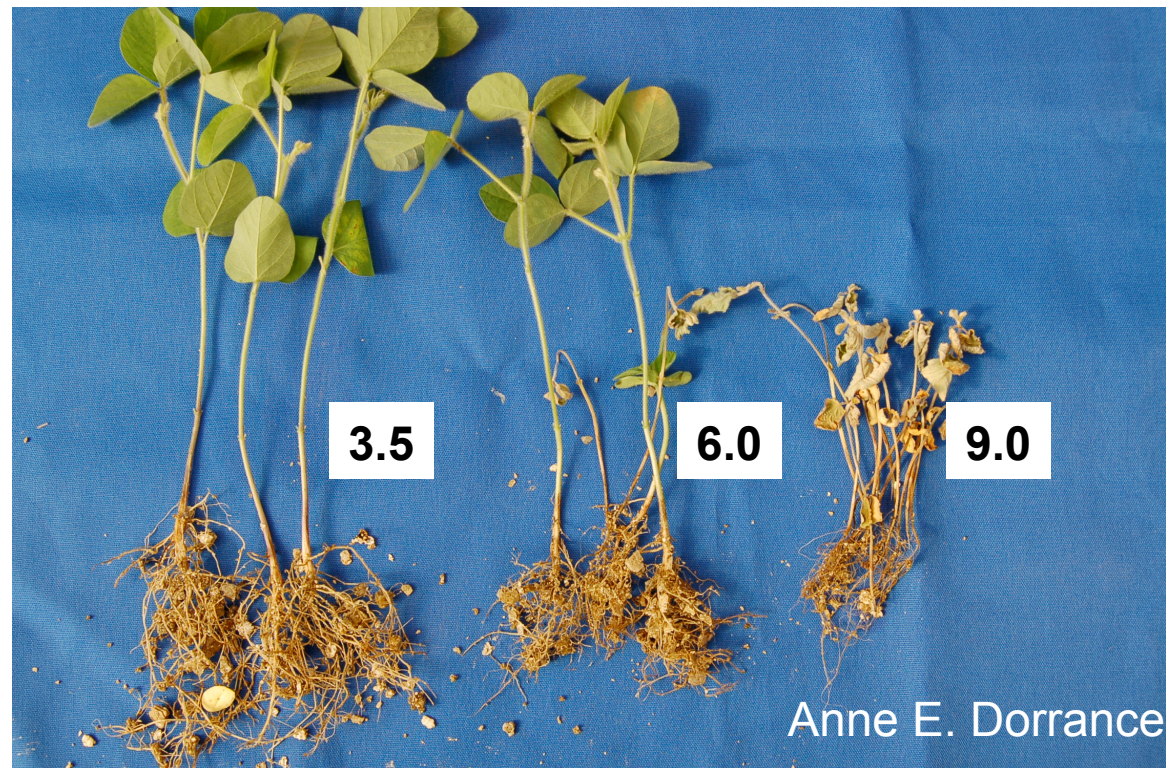
■ =Rps1k

Layer Test

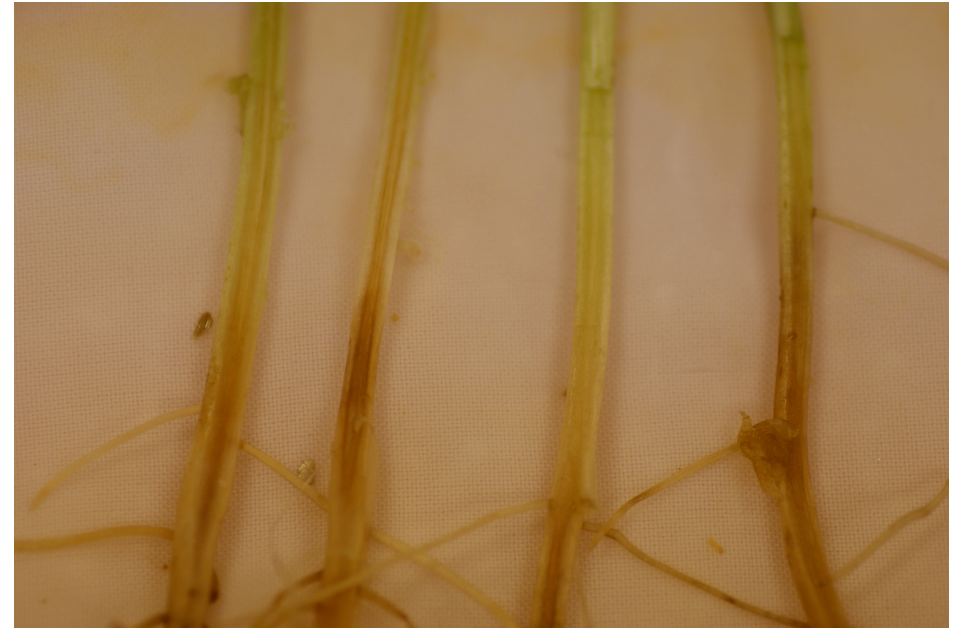


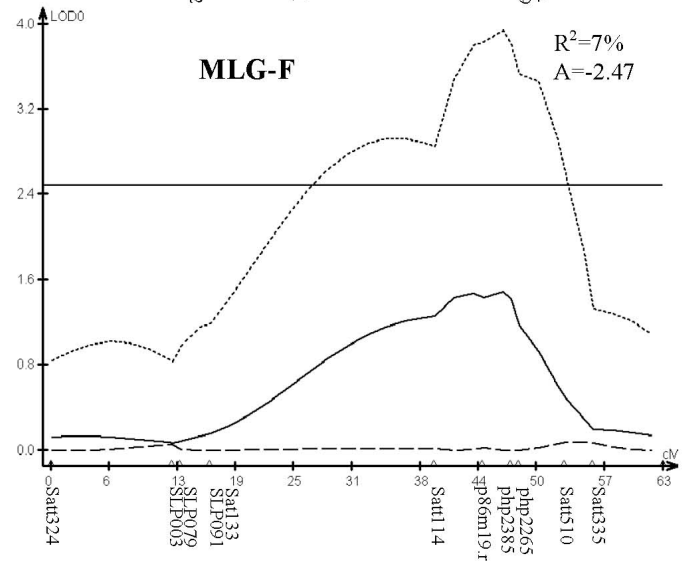
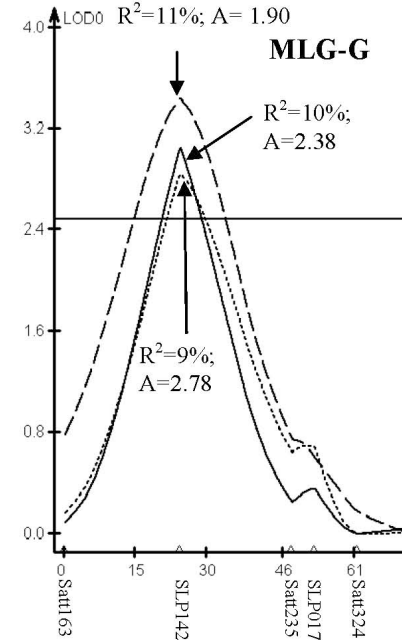
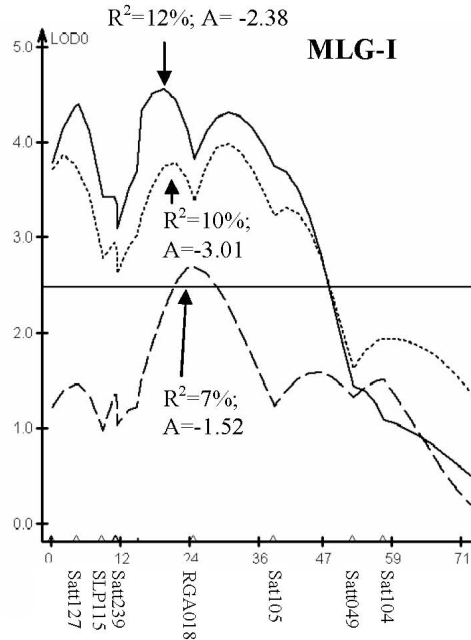
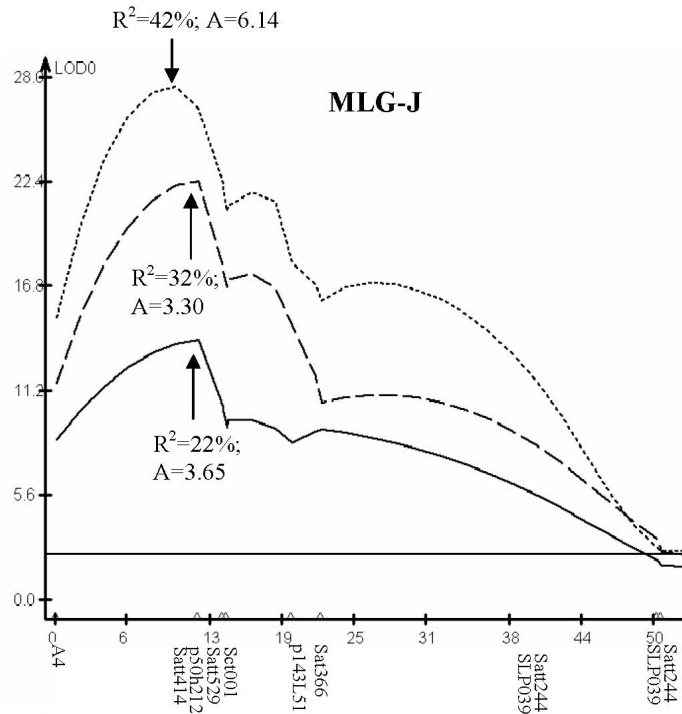
Partial Resistance

- Field resistance, tolerance
- Multigenic
- Layer test



Tray Test



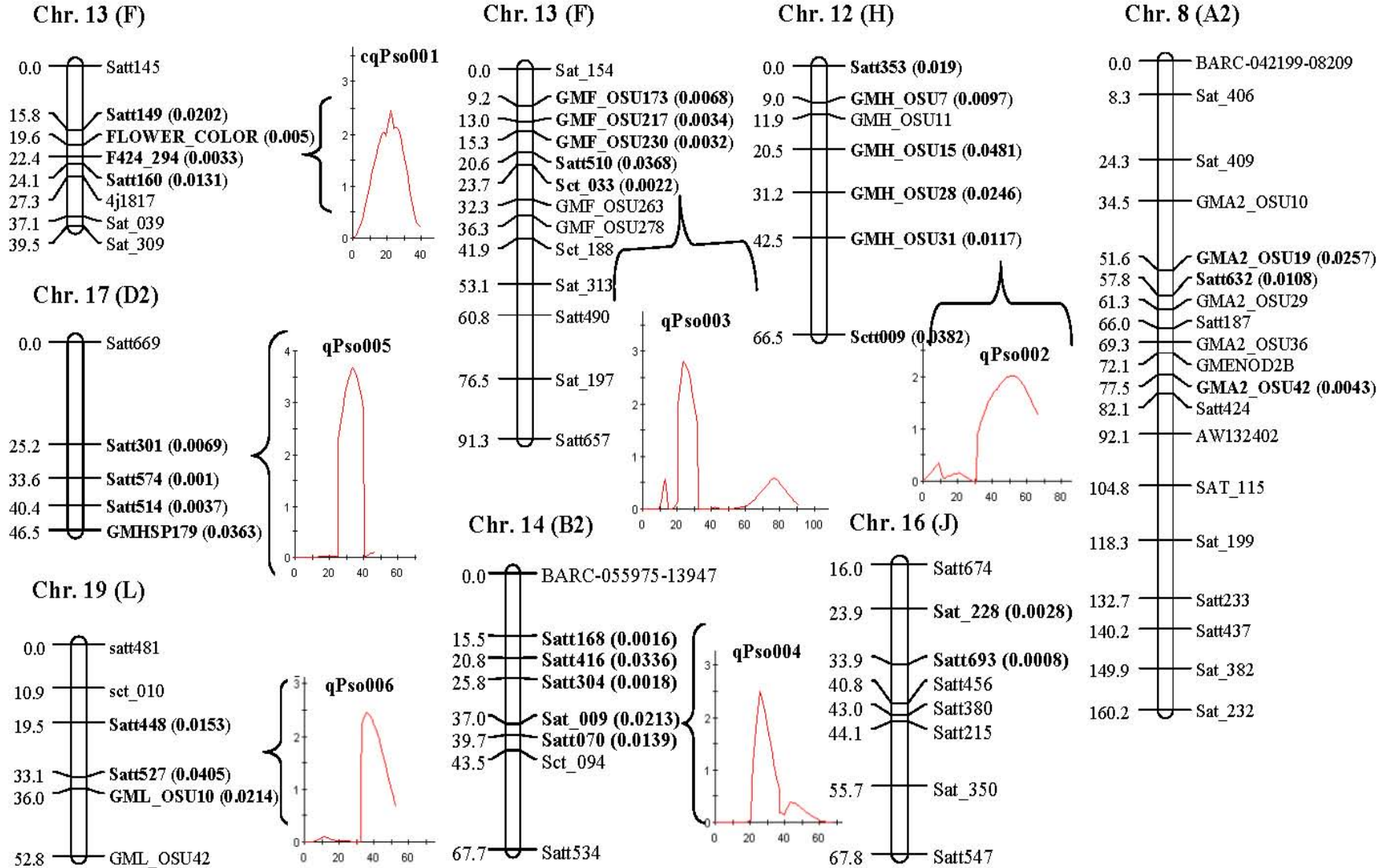


- - - 2005 BLUP Lesion
 . . . 2006A BLUP Lesion
 - - - 2006B BLUP Lesion

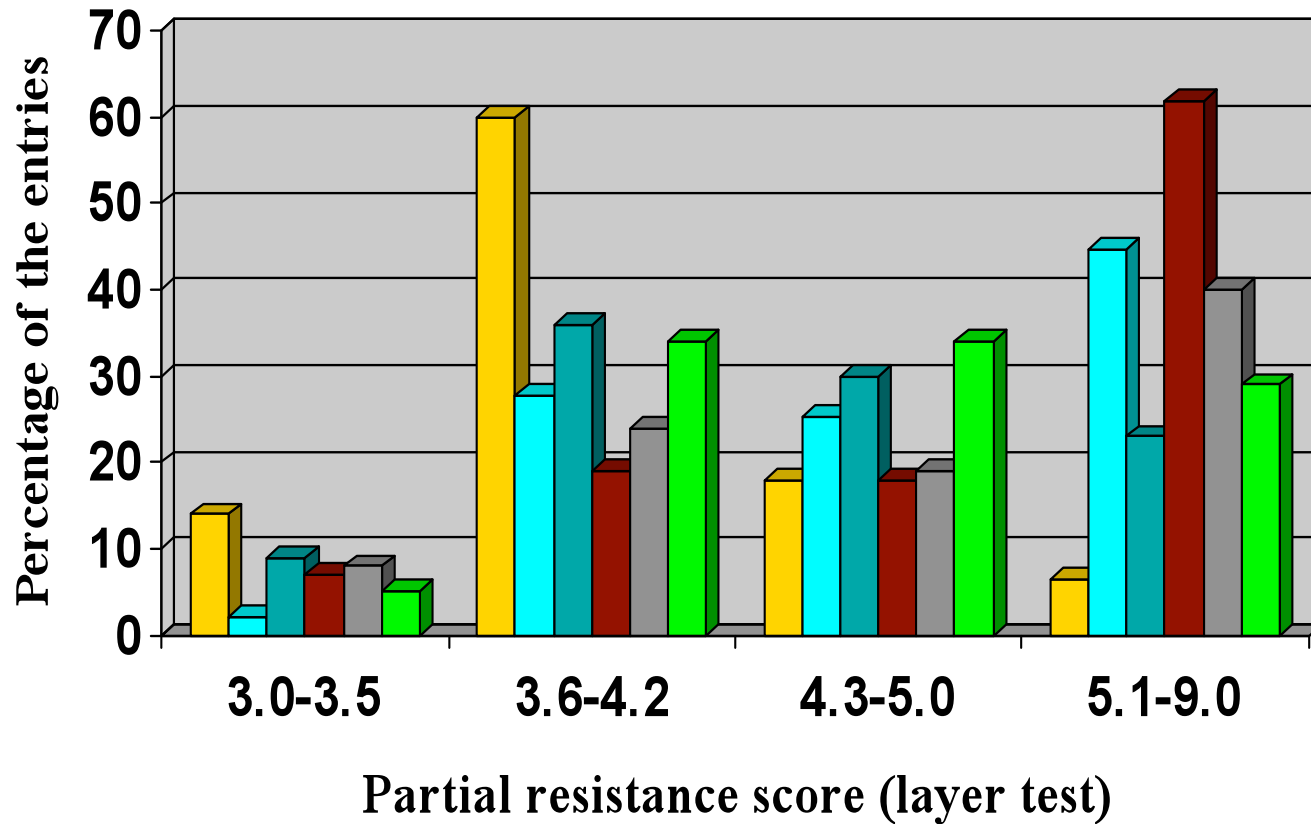
V71-370 x *G. soja*
 Tucker et al., 2010 *Crop Science*



Conrad x Sloan, F_{4:6}, 182 RILs



Partial resistance levels in Ohio Soybean Performance Trials



- Steve St. Martin, HCS
- Rouf Mian, USDA-ARS
- Maria Andrea Ortega
- Sue Ann Berry
- Zhifen Zhang
- Hehe Wang
- Santiago Mideros Mora
- Dominic Tucker, VaTech
- M.A. Saghai Maroof, VaTech
- Randy Shoemaker, USDA-ARS
- Perry Cregan, USDA-ARS
- David Hyten, USDA-ARS
- Michelle Graham, USDA-ARS

- Welcome
- Leah McHale

Thank You!



Percentage of fields where soybeans with *Rps* genes may be susceptible-2003



State	# fields	# <i>P. sojae</i>	<i>Rps</i> 1a	<i>Rps</i> 1c	<i>Rps</i> 1k	<i>Rps</i> 3a	<i>Rps</i> 6
OH	9	116	60	50	50	20	50
IL	24*	121	58	41	37	7	9
IA	41	63	74	53	55	11	24
IN	190	200	80	40	50	13	47
MO	58	60	67	53	55	47	36
N.D.	252	153	31	18	5.5	0.3	2
S.D.	46	124	98	77	75	81	41
Ontario, Canada	15	50	87	47	0	Nt	53

Where do *Rps* genes originate

... 8 of 14 from China

Gene	Source (s)	
<i>Rps1a</i>	Mukden	Liaoning, China
<i>Rps1b</i>	PI 84637 D60-9647	South Korea
<i>Rps1c</i>	PI 54615-1,	Heilongjiang, China
<i>Rps1d</i>	PI103091,	Henan, China
<i>Rps1k</i>	Kingwa	Beijing, China
<i>Rps2</i>	CNS	Jiangsu, China
<i>Rps3a</i>	PI 86972-1 PI 171442	South Korea Shaanxi, China
<i>Rps3b</i>	PI 172901	Turkey
<i>Rps3c</i>	PI 340046	Kyonggi, South Korea
<i>Rps4</i>	PI 86050 ^a genes)	Hokkaido, Japan (actually 2
<i>Rps5</i>	L62-904	Liaoning, China
<i>Rps6</i>	Altona	Sweden
<i>Rps7</i>	Harosoy	Heilongjiang, China
<i>Rps8</i>	PI 399073	South Korea

Partial Resistance to *P. sojae*

- Control
- Score 3.5, only feeder roots
- Score 4.5, more roots are rotted
- Score 6.0, ½ plants are dead, very few roots



How many *Rps* genes are present in Chinese germplasm--

Province	No.	Race 1	Race 3	Race 7	Race 25	Citation
Anhui	67	90	72	75	46	Lohnes et al., 1996
Anhui	69	72	59	49	22	Kyle et al., 1998
Gansu	91	16	14	16	8	Lohnes et al., 1996
Guangdong	9	11	11	0	11	Kyle et al., 1998
Hebei	46	41	41	72	7	Lohnes et al., 1996
Henan	109	65	38	57	21	Lohnes et al., 1996
Hubei	173	80	62	50	28	Kyle et al., 1998
Jiangsu	73	71	44	77	21	Lohnes et al., 1996
Jiangsu	167	65	46	34	32	Kyle et al., 1998
Ninxia	24	67	42	75	0	Lohnes et al., 1996
Shaanxi	67	42	34	37	1	Lohnes et al., 1996
Shandong	138	54	45	56	9	Lohnes et al., 1996
Shanghai	7	29	14	14	29	Kyle et al., 1998
Shanxi	95	26	21	56	2	Lohnes et al., 1996
Sichuan	130	44	32	34	30	Kyle et al., 1998
Zhejiang	73	48	40	33	32	Kyle et al., 1998