



Studies of late blight in Taiwan

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Severely Devastated in The Field



A total of 990 isolates were collected (tomato: 930; potato: 60)



Pathogen: *Phytophthora infestans*

- Oomycetes
- Grow in media: rye A agar, lima bean agar, frozen pea agar
- Reproduction:
 - oospores for sexually
 - sporangia and zoospores for asexually
- Sporangiophore: long, emerges from leaf stomata
- Sporangia: hyaline, thin-walled, lemon-shaped
 - germinate directly to produce a germ tube
 - germinate to produce up to 8 zoospores when exposed to cool, moist conditions
- Zoospores: may swim with 2 flagella





- **New population quickly displaced the old population wherever new strain disspreading.**
- **This took place over only a few years and in most cases new populations completely displaced old ones.**
- **Up to now A2 has not been detected in Taiwan.**

- **Severity rating scales**

0 = no symptoms

1 = $\leq 5\%$ of leaf area affected; small lesions

2 = 6-15% of leaf area affected; restricted lesion

3 = 16-30% of leaf area affected; no deep stem lesions

4 = 31-60% of leaf area affected; and/or few small stem lesions

5 = 61-90% of leaf area affected; and/or expanding stem lesions

6 = 91-100% of leaf area affected; and/or extensive stem damage, or plant dead





Physiological Race Determination

- Tomato differentials

Accession no.		Genotype
TS19	<i>S. esculentum</i>	<i>Ph+</i>
TS33	<i>S. esculentum</i>	<i>Ph-1</i>
W. Va. 700	<i>S. pimpinellifolium</i>	<i>Ph-2</i>
CLN2037B	<i>S. esculentum</i>	<i>Ph-3</i>
L3708	<i>S. pimpinellifolium</i>	<i>Ph-3,4(?)</i> ¹
LA1033	<i>S. habrochaites</i>	<i>Ph-5(?)</i> ²

^{1,2} Gene(s) conditioning late blight resistance in this accession are not yet characterized.



- **Determination of physiological races**

A mean severity of over 3.5 on a differential was evaluated as a defeated resistance gene.

The race designation is derived from the resistance genes that are defeated by the isolate.

For instance, tomato race T1,2 will overcome the resistance of TS33 and W. Va. 700, which possess the *Ph-1* and *Ph-2* genes, respectively.



Genotype characterization of *P. infestans* population

The genotypes of *Phytophthora infestans* identified in Taiwan from 1991 to 2008

Genotype	Mating type	Metalaxyl sensitivity	Allozyme genotype		mtDNA haplotype	RG57 fingerprint
			<i>Gpi</i>	<i>Pep</i>		
US-1	A1	S/I	86/100	92/100	Ib	1010101011001101000110011
US-1.1	A1	S/I	86/100	100/100	Ib	1010101011001101000110011
US-1.2	A1	S/I	86/100	92/100	Ib	1010101010001101000110011
US-1.3	A1	S	86/100	92/100	Ib	1010101001001101000110011
US-1.4	A1	S	86/100	100/100	Ib	1010101010001101000110011
US-11	A1	I/R	100/100/111	100/100	IIb	1010111001001101010110011
US-11.1	A1	I/R	100/100/111	100/100	IIb	1010011001001101010110011
US-11.2	A1	R	100/100/111	100/100	IIb	1010111000011101010110011
US-11.3	A1	R	100/100/111	100/100	IIb	1010111000001101010110011
US-11.4	A1	R	100/100/111	100/100	IIb	1010111001001101000110011
US-11.5	A1	I/R	100/100/111	100/100	IIb	1010111001011101010110011
TW-1	A1	R	100/122	100/100	IIb	1010111001001101010110011



The genotypes of *Phytophthora infestans* identified in Taiwan from 1991 to 2008

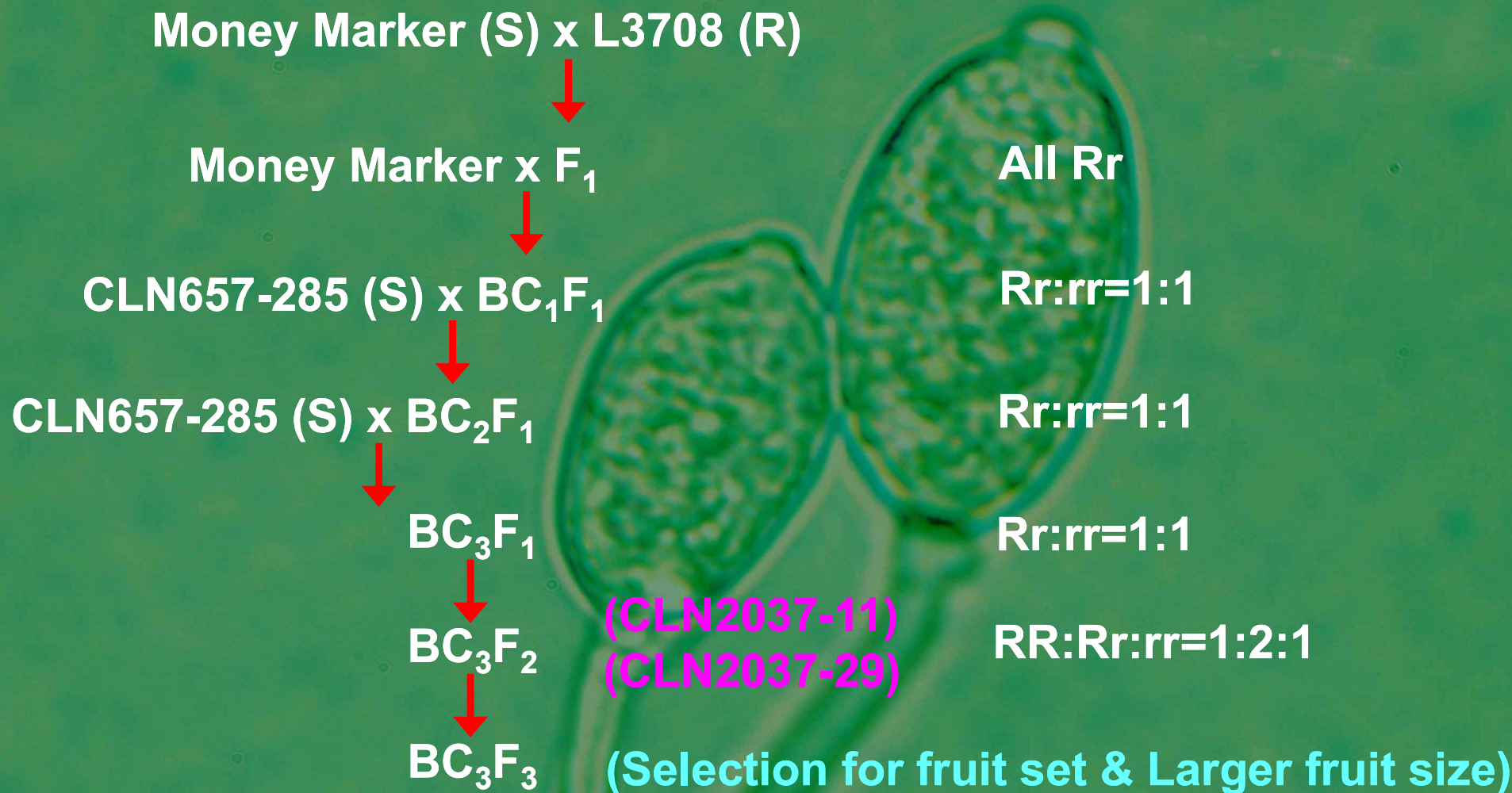
Year	US-1	US-1.1	US-1.2	US-1.3	US-1.4	US-11	US-11.1	US-11.2	US-11.3	US-11.4	US-11.5	TW-1
1991-1997	15	8	2	2	1							
1998	3	2				20	2	1	3	1		1
1999	1					19	2	2				
2000						33	4					
2001						52	4	2				
2002	1					41	10	6				
2003	1					83	7	10				
2004						79	4	27				3
2005						69	5	25	6	1		
2006						56	6	36				
2007						32	3	19			1	
2008						32		50			22	
Total	21	10	2	2	1	516	47	178	9	2	23	4

A total of 815 isolates were characterized.



Development of Resistance Lines

- **L3708** was used as the donor parent and resistance was introgressed into tomato by backcrossing and selection with a race T1, 2 isolate. Moneymaker was the parent for the cross and first backcross; the second and third backcross were carried out with AVRDC line CLN 657-285-0-21-0.





- Six BC3F6 lines, CLN 2037B, CLN2037C, CLN2037E, CLN2037G, CLN2037H, and CLN2037I were selected and exhibited highly resistance to race T1, 2,3. These lines are also resistance to multiple strains of tobacco mosaic virus. They were chosen for international distribution and testing. These lines carry the *ph-3* gene for race-specific late blight resistance.



- Five F1 populations (FM TT791, 792, 793, 794, and 795) derived from CLN2037 lines (Resistant) x L4783 (Fresh market tomato, susceptible) also exhibited to carry the *Ph-3* gene for race-specific late blight resistance under field conditions. FM TT795 was named Hualien ASVEG No.17 in Taiwan, Dec. 2005.



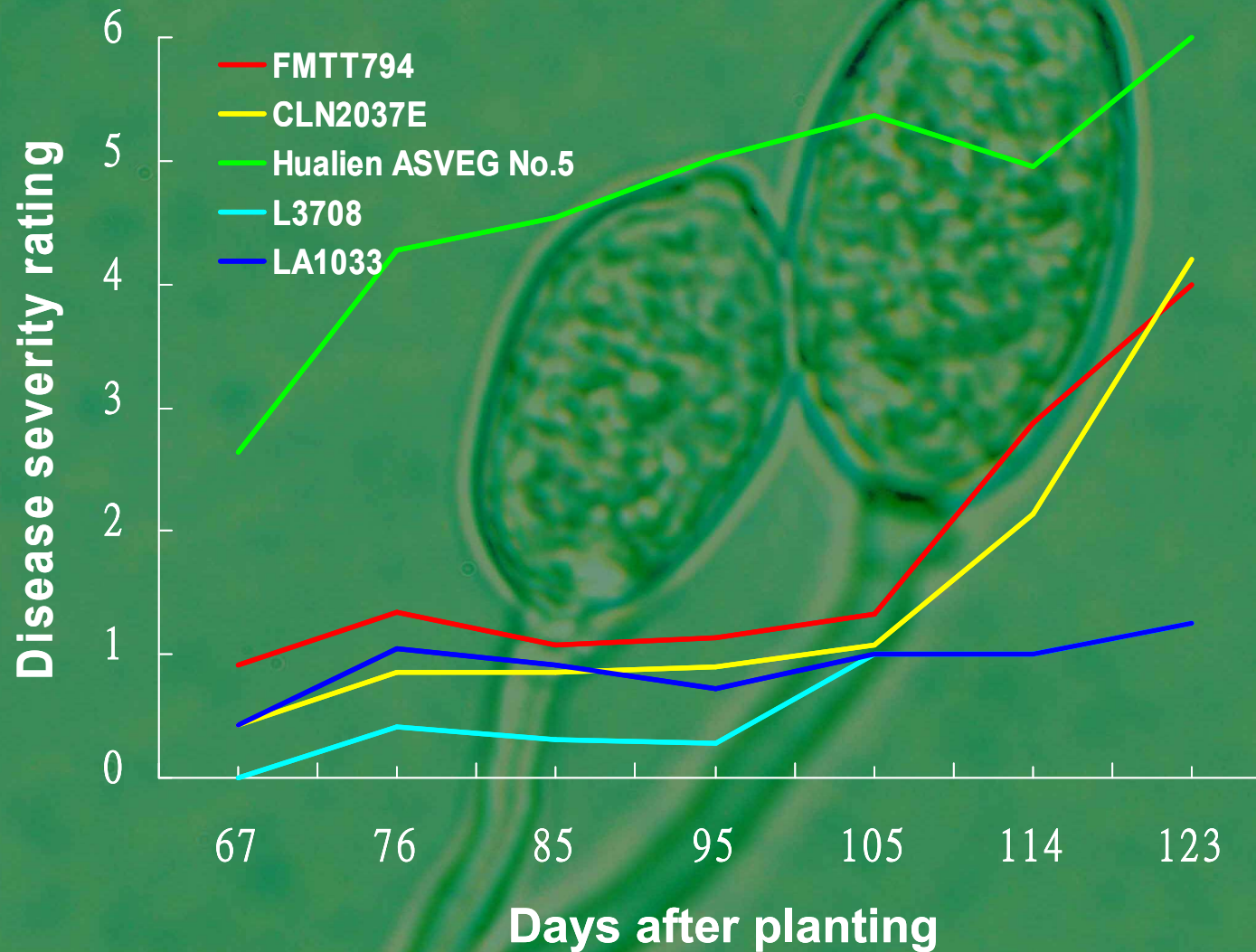


Evaluation for durable resistance of tomato late blight at Hualien DAIS, TSSS ,and PBS of Taichung DAIS December 2001-May 2002

Entry	Area under disease progress curve (AUDPC)		
	Hualien DAIS	TSSS	PBS
CLN2037 B	70.0 cd	61.0 d	20.1 c-e
CLN2037 E	60.8 de	61.0 d	5.6 de
FMTT791 F ₁	86.3 c	69.3 d	- c-e
FMTT792 F ₁	80.9 c	66.5 d	30.6 c-e
FMTT793 F ₁	82.6 c	66.5 d	26.8 c-e
FMTT794 F ₁	82.1 c	66.5 d	29.2 c-e
Hualien ASVEG #5	263.3 a	-	-
Taichung ASVEG #4	-	257.9 ab	141.5 a
L 3708	32.4 f	0.0 e	0.0 e
LA 1033	50.2 ef	61.0 d	13.8 c-e
TS 19	248.3 ab	247.1 b	134.9 ab
TS 33	233.5 b	276.9 a	120.2 ab
W.Va.700	86.4 c	113.0 c	39.6 cd

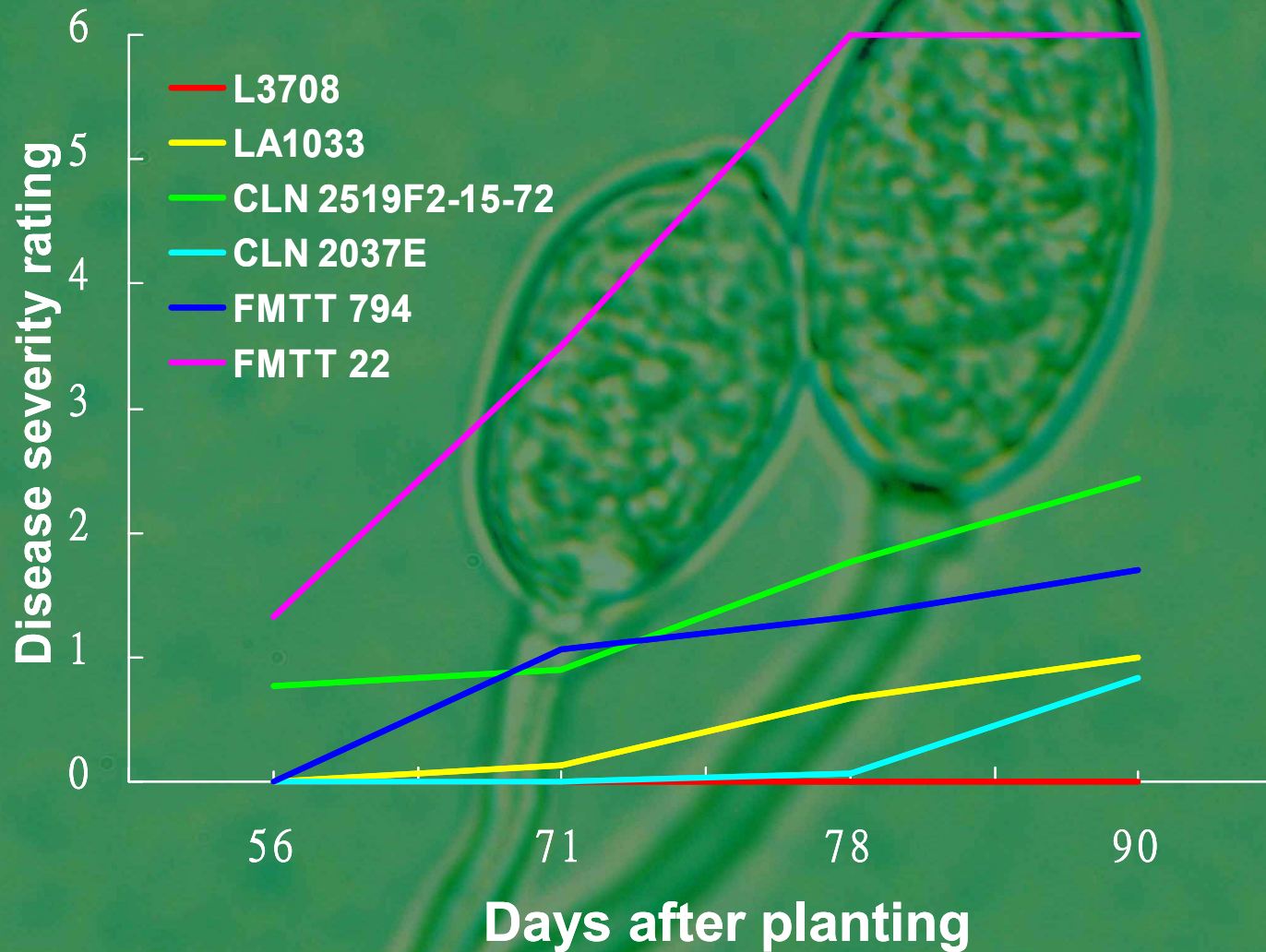


Evaluation for durability of late blight resistance Hualien DAIS, Spring 2002



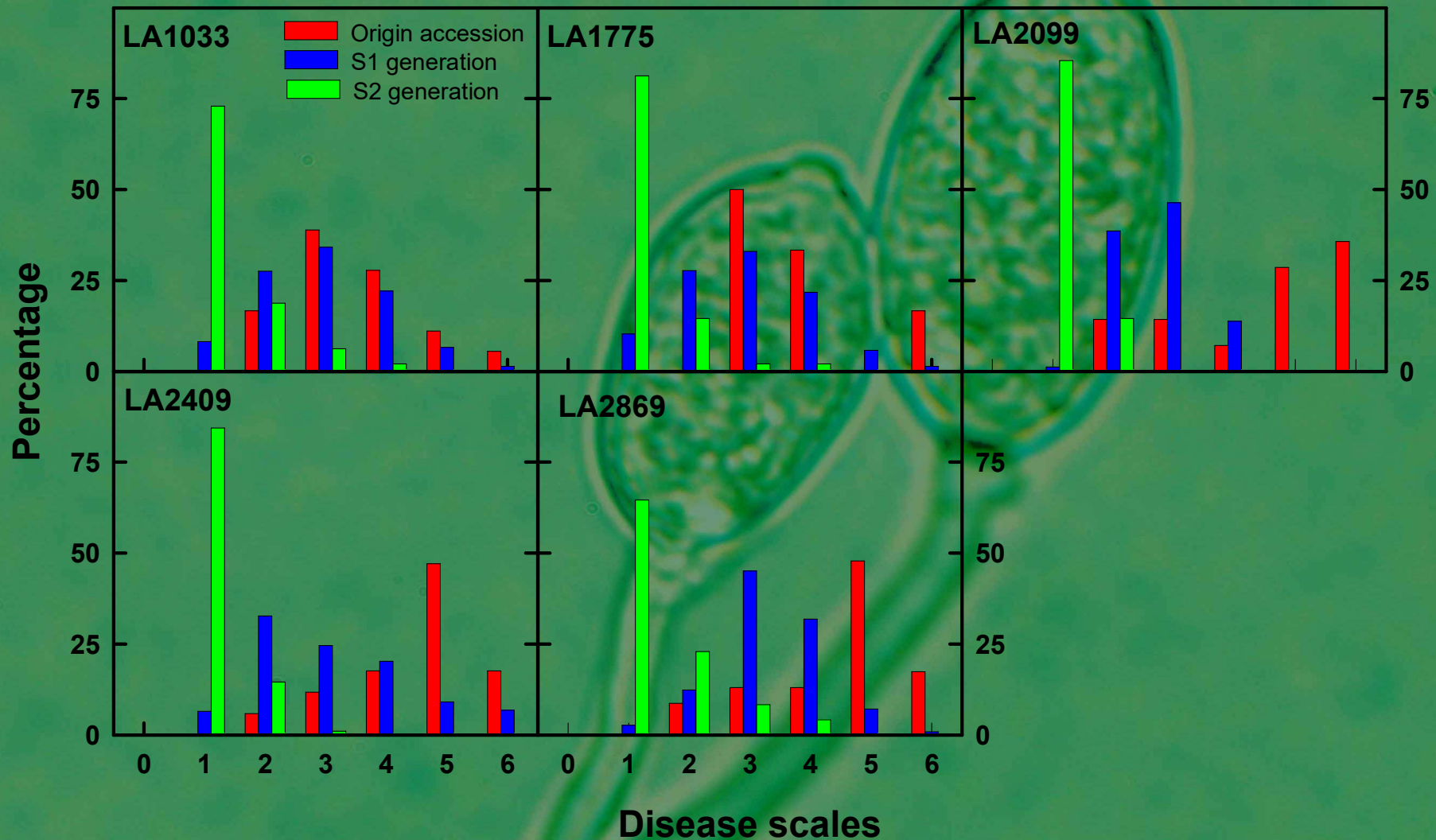


Evaluation for durability of late blight resistance Puli Branch Station, Taichung DAIS, March-June 2002



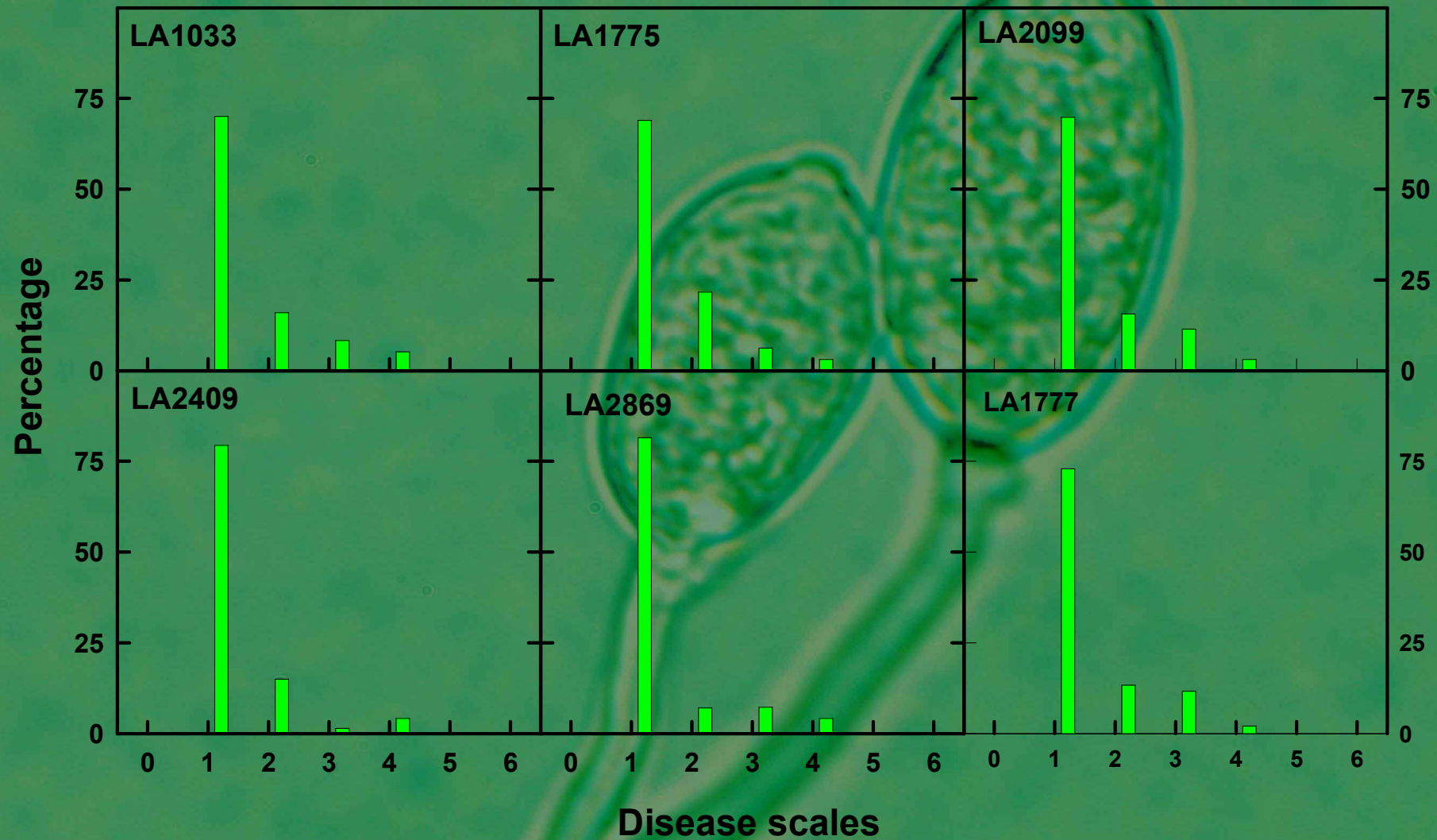


Screening wild resistant sources





Screening wild resistant sources





Pi-411



LA1033s LA1775 LA1777 LA2099 LA2409 LA2869 LA1033 L3708



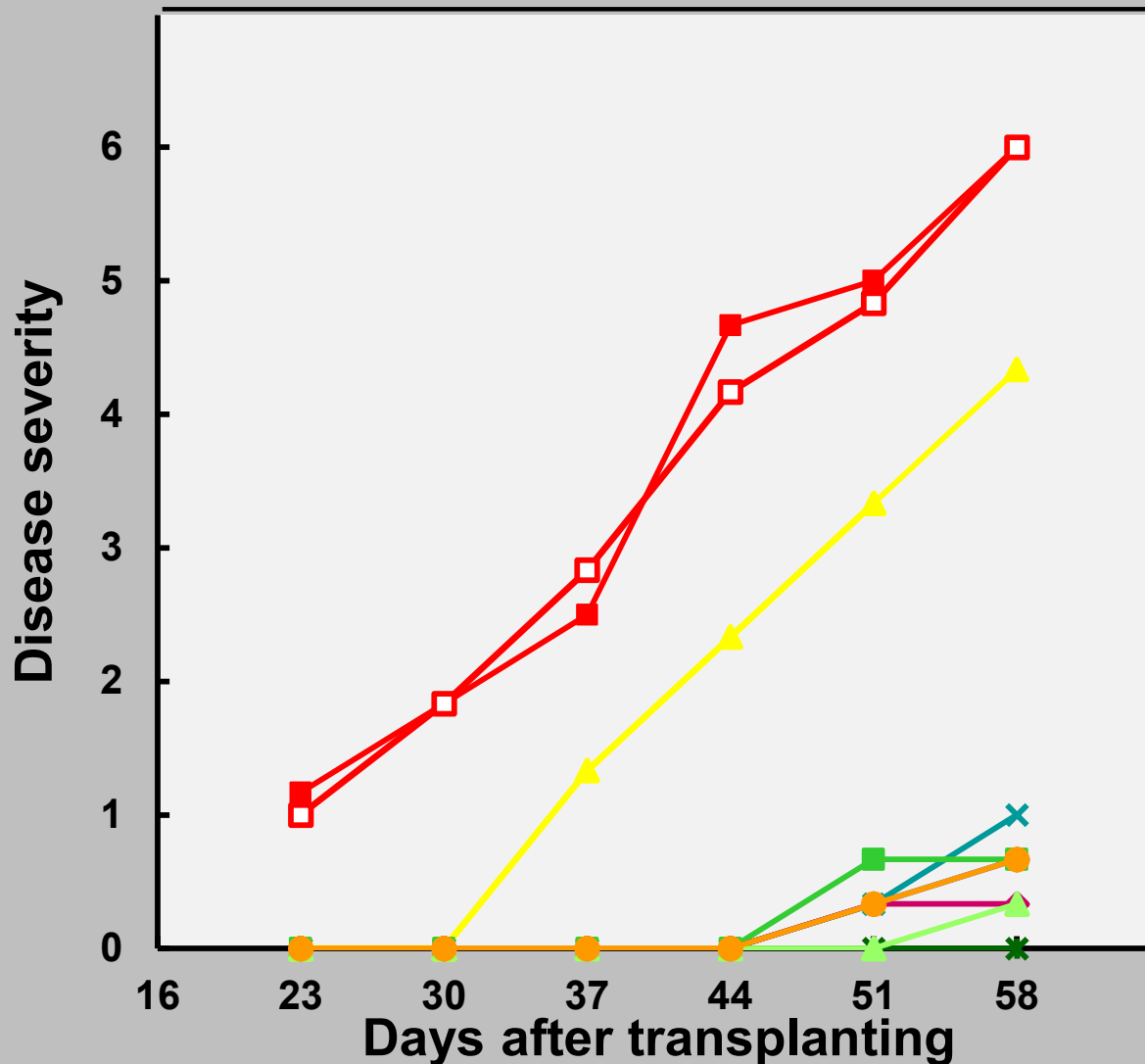
Pi-858



LA1033s LA1775 LA1777 LA2099 LA2409 LA2869 LA1033 L3708



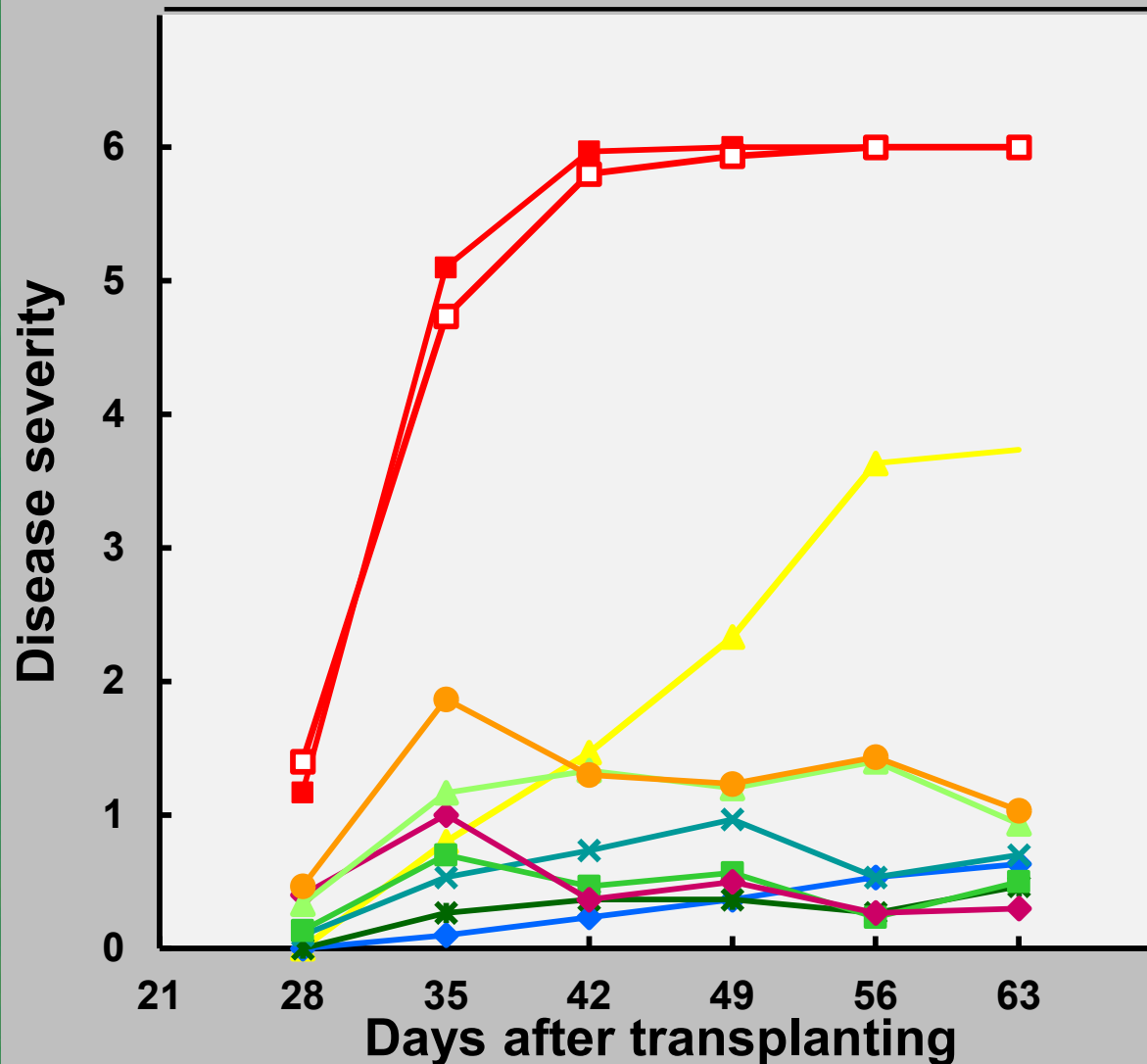
Disease progress for the S3 lines in the field, 2015 spring in AVRDC



Entry	AUDPC	Significance
TS19	123.08	a
TS33	120.17	a
WVa700	64.17	b
CLN2037B	4.67	cd
L3708	0.00	d
LA1033	5.83	c
LA1775	7.00	c
LA2099	3.50	cd
LA2409	1.17	cd
LA2869	4.67	cd



Disease progress for the S3 lines in the field, 2015 spring in Hualien DARIS



Entry	AUDPC
■ TS19	186.55 a
□ TS33	183.17 a
▲ WVa700	70.70 b
◆ CLN2037B	10.85 d
✱ L3708	10.50 d
✕ LA1033	22.17 cd
■ LA1775	15.98 d
◆ LA2099	17.38 d
▲ LA2409	40.13 c
● LA2869	46.08 c



Fungicides efficacy test in the field

Tomato lines	Treatment	AUDPC
FMTT795 (resistant)	50%(Famoxadone+Cymoxanil) SC	40.83 b
	Supa Stand Phos	71.17 ab
	23% Azoxystrobin SC	40.83 b
	50% Dimethomorph WP	51.33 b
	Neutralized phosphorus salt (NPS)	60.67 b
	Control	98.00 a
Tauyuan ASVEG No. 9 (susceptible)	50%(Famoxadone+Cymoxanil) SC	47.83 e
	Supa Stand Phos	162.17 bc
	23% Azoxystrobin SC	79.33 de
	50% Dimethomorph WP	134.17 cd
	Neutralized phosphorus salt (NPS)	211.50 b
	Control	410.33 a



- **Cyazofamid** showed as effective as Famoxadone+Cymoxanil on controlling tomato late blight in the growth chamber.



Studies on Non-pesticide Control

- ***Antagonists*** (*Streptomyces* spp., *Bacillus* spp., and *Trichoderma* spp., etc)
- **Neutralized phosphorus salt (NPS)**
- **Phytochemical water extract** (Chiese herb extract)



- Severity of tomato late blight was significantly reduced by NPS treatment in Bali.





- Tomato late blight was significantly inhibited by *Streptomyces saraceticus* strain S-31, Oughon (*Scutellaria baicalensis* Georgi), and cyazofamid in the growth chamber.

