IMPROVING RESISTANCE TO FUSARIUM WILT RACE THREE OF TOMATO

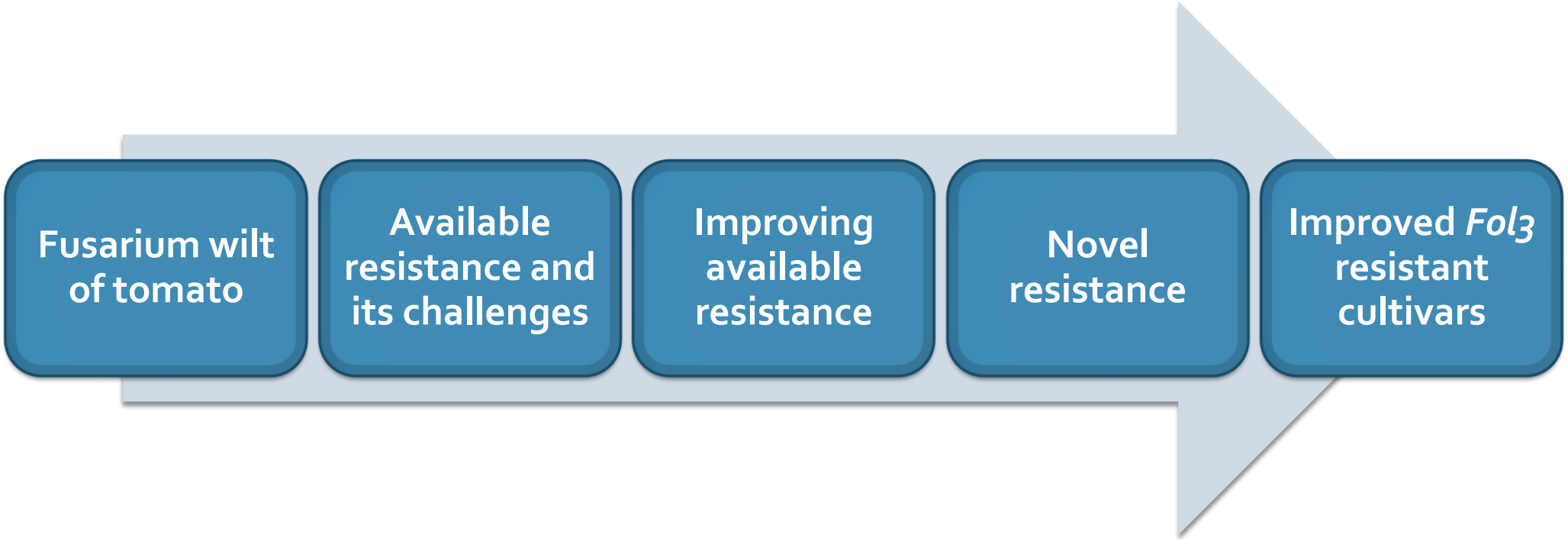
Jessica Chitwood-Brown

Tomato Breeders Roundtable Meeting 2018

J. Lee, S.F Hutton, T. G. Lee, and G.E. Vallad

Gulf Coast Research and Education Center, University of Florida

Outline


Fusarium wilt of tomato
Available resistance and its challenges
Improving available resistance
Novel resistance
Improved *Fol3* resistant cultivars

Tomatoes in Florida

Photo credit: J. Chitwood-Brown

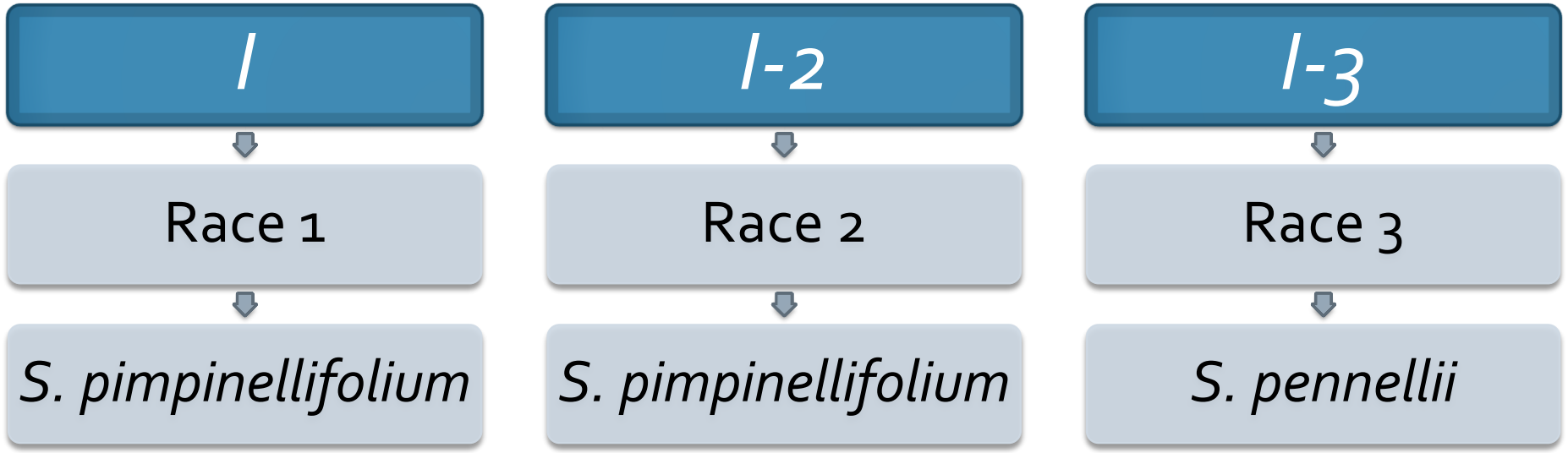
Fusarium wilt in tomato

- *Fusarium oxysporum* f. sp. *lycopersici* (*Fol*)
  - Soilborne fungus – colonizes vascular tissue
  - Forms chlamydospores
  - Chlorosis, wilting, stunting, vascular browning, plant death
- Management
  - Fumigation
    - Phase-out of methyl bromide
  - Host resistance is most effective
- Three races

Photo credit: http://plantpath.ifas.ufl.edu/u-scout/Toma


Photo credit: J. Chitwood-Brown

Genetic resistance



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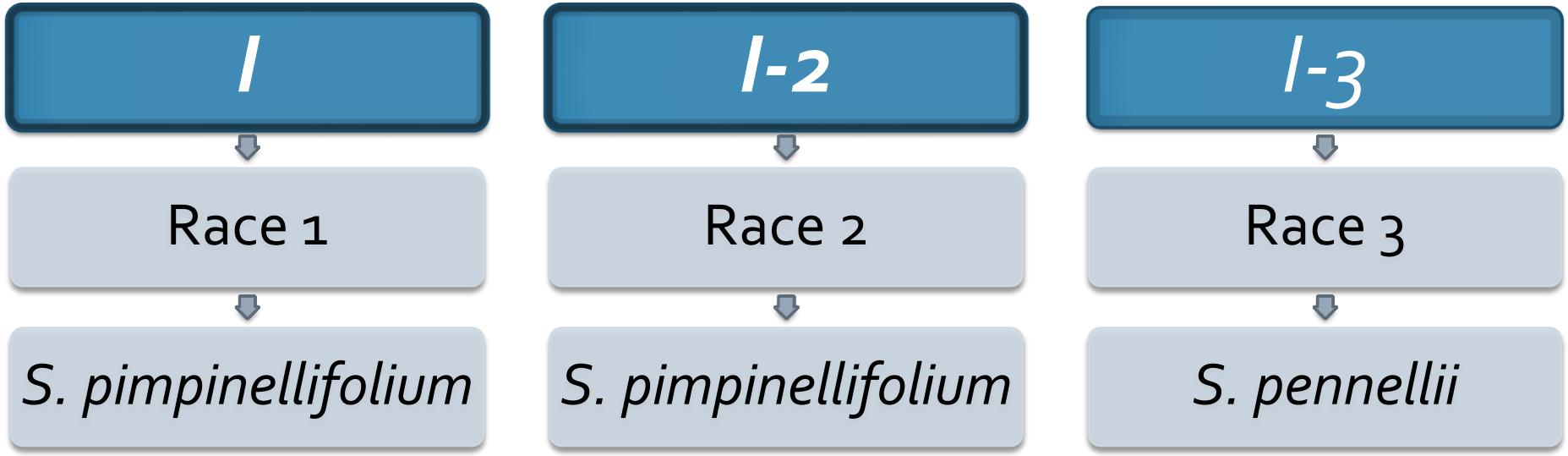

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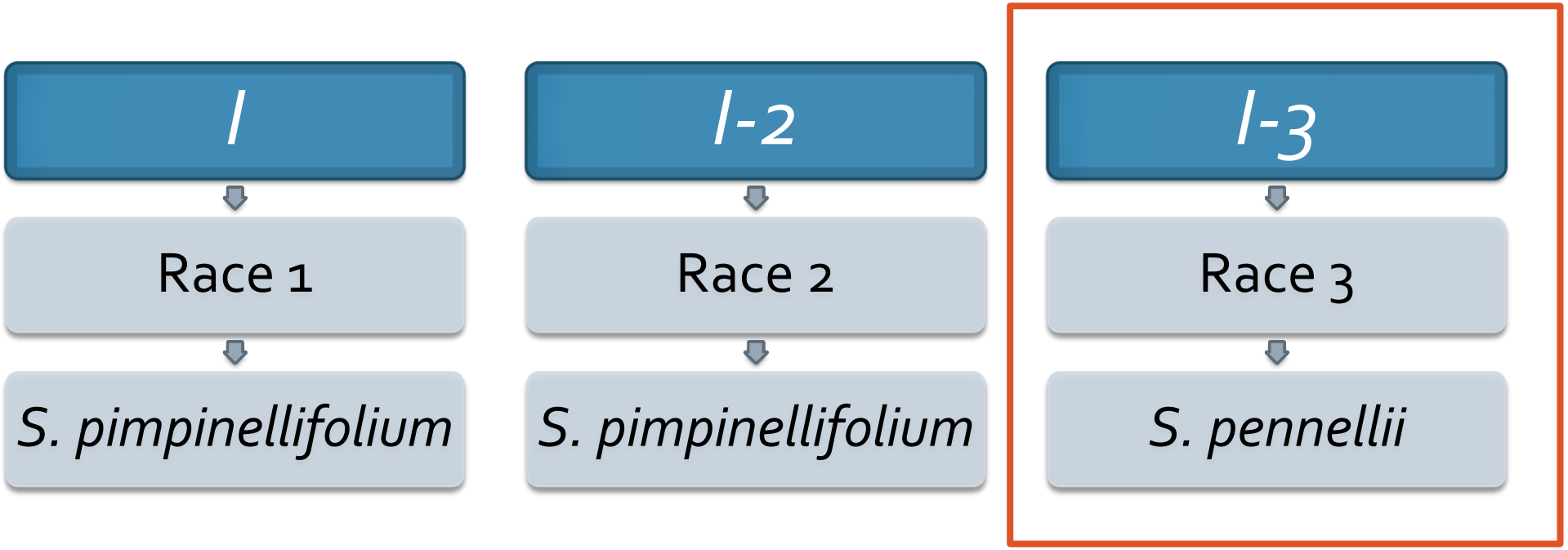

Focusing on race 3 (*Fol3*) resistance

Genetic resistance

- *I-3* cultivars available since the 1990's
  - Associated with negative traits
  - Increased sensitivity to bacterial spot

Photo credit: Li et al. 2013

Genetic resistance

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  - Associated with negative traits
  - **Increased sensitivity to bacterial spot**

Photo credit: Li et al. 2016

J. Amer. Soc. Hort. Sci. 139(3):282–289. 2014.

Association of the Fusarium Wilt Race 3 Resistance Gene, *I-3*, on Chromosome 7 with Increased Susceptibility to Bacterial Spot Race T4 in Tomato

Samuel F. Hutton[1], John W. Scott, and Gary E. Vallad
Gulf Coast Research and Education Center, Institute of Food and Agricultural Sciences, University of Florida, 14625 CR 672, Wimauma, FL 33598-6101

Additional index words. broad-spectrum resistance, linkage drag, pleiotropy, quantitative trait loci, *Xanthomonas*

Abstract. **Bacterial spot of tomato (*Solanum lycopersicum*), caused by several *Xanthomonas* species, is one of the most important diseases of the crop in humid production regions of the world. Conventional breeding approaches for resistance to bacterial spot previously identified race-specific resistances, but current efforts also seek to use quantitative trait loci (QTLs) effecting broad-spectrum resistance. Resistance QTLs and candidate QTLs have been**

Genetic resistance

- *I-3* cultivars available since the 1990's
  - Associated with negative traits
  - Increased sensitivity to bacterial spot
  - **Reduced fruit size**
    - 1999

Proc. Fla. State Hort. Soc. 112:305-307. 1999.

TOMATO PLANTS HETEROZYGOUS FOR FUSARIUM WILT RACE 3 RESISTANCE DEVELOP LARGER FRUIT THAN HOMOZYGOUS RESISTANT PLANTS

J. W. SCOTT
University of Florida
Gulf Coast Research and Education Center
Bradenton, FL 34203-9434

Additional index words. Fusarium oxysporum f. sp. *lycopersici*, hybrid, *Lycopersicon esculentum*, yield.

The race 2 resistance gene has been mapped to chromosome 11 by morphological (Laterrot, 1976) and DNA markers (Sarfatti et al., 1989). In 1982 Fusarium wilt race 3 was reported in Florida (Jones et al., 1982) and Australia (Grattidge and O'Brien, 1982). A single dominant resistance gene (*I-3*) was reported in *L. pennellii* (Corr.) D'Arcy accessions PI 494773 by McGrath et al. (1987) and in LA 716 by Scott and Jones

Genetic resistance

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HortScience 39(2):440–441. 2004.

Fla. 7946 Tomato Breeding Line Resistant to *Fusarium oxysporum* f.sp. *lycopersici* Races 1, 2, and 3

J.W. Scott
Gulf Coast Research and Education Center, 5007 60th Street East, University of Florida, Bradenton, FL 34203

Additional index words. blossom-end rot, cultivar, disease resistance, fruit size, fusarium wilt, *Lycopersicon esculentum*

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LANTS

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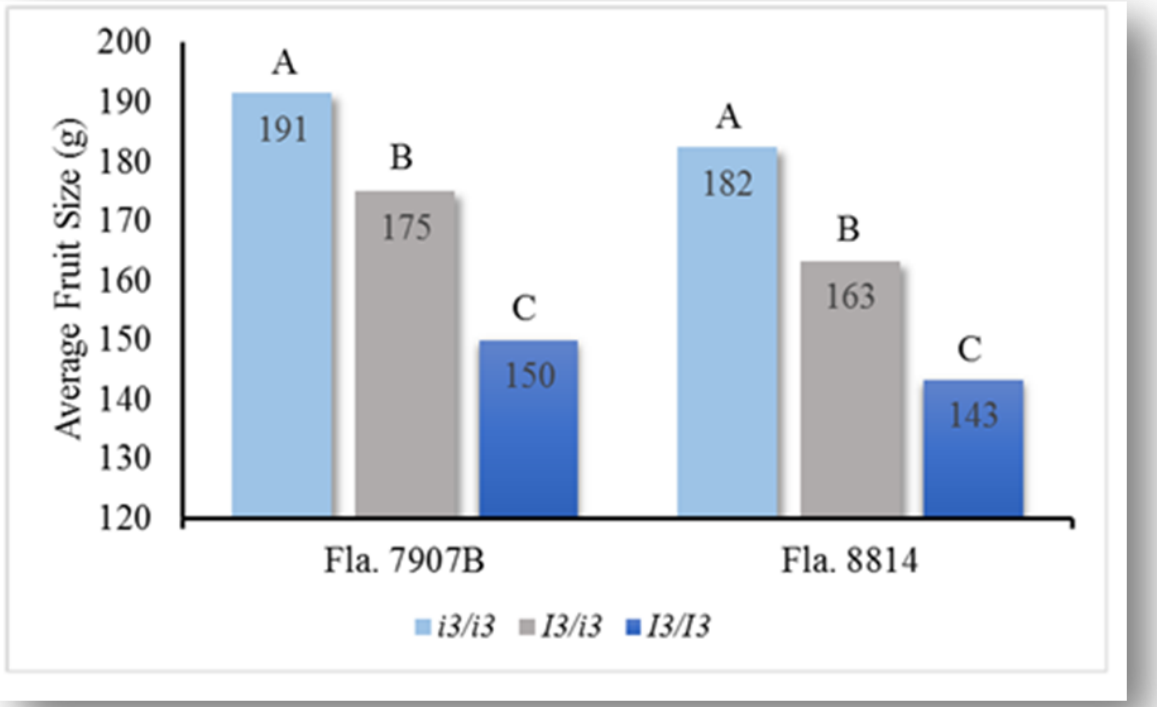
    - 20+ years of breeding later



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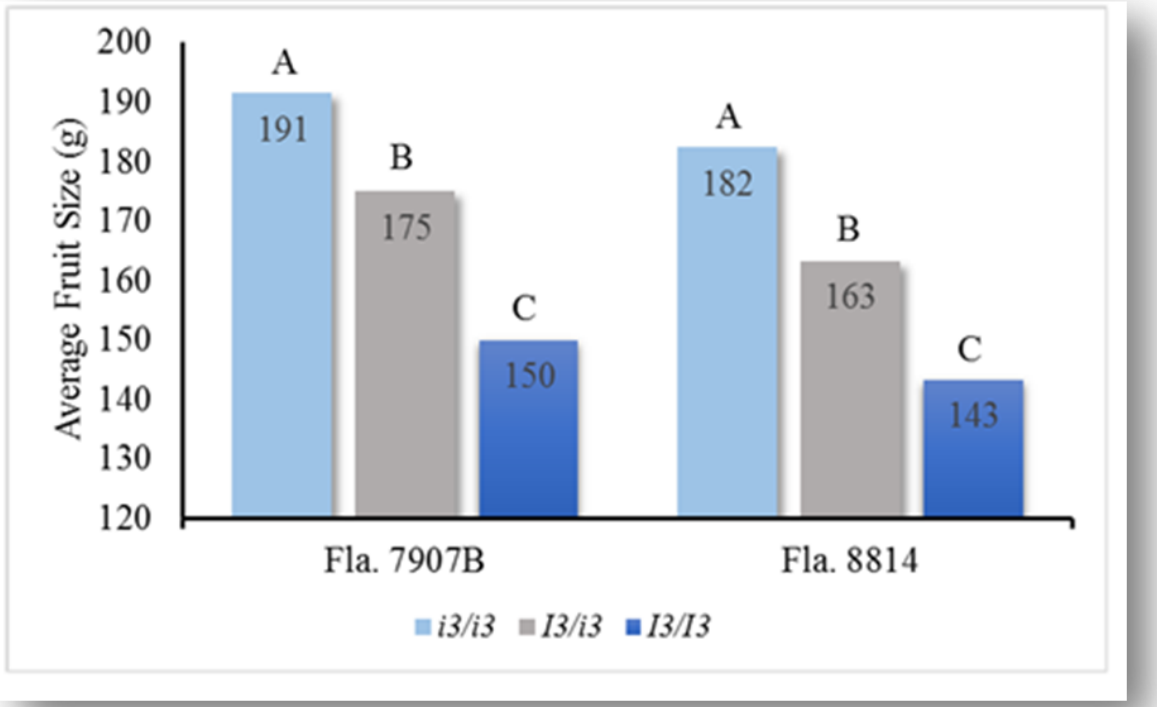
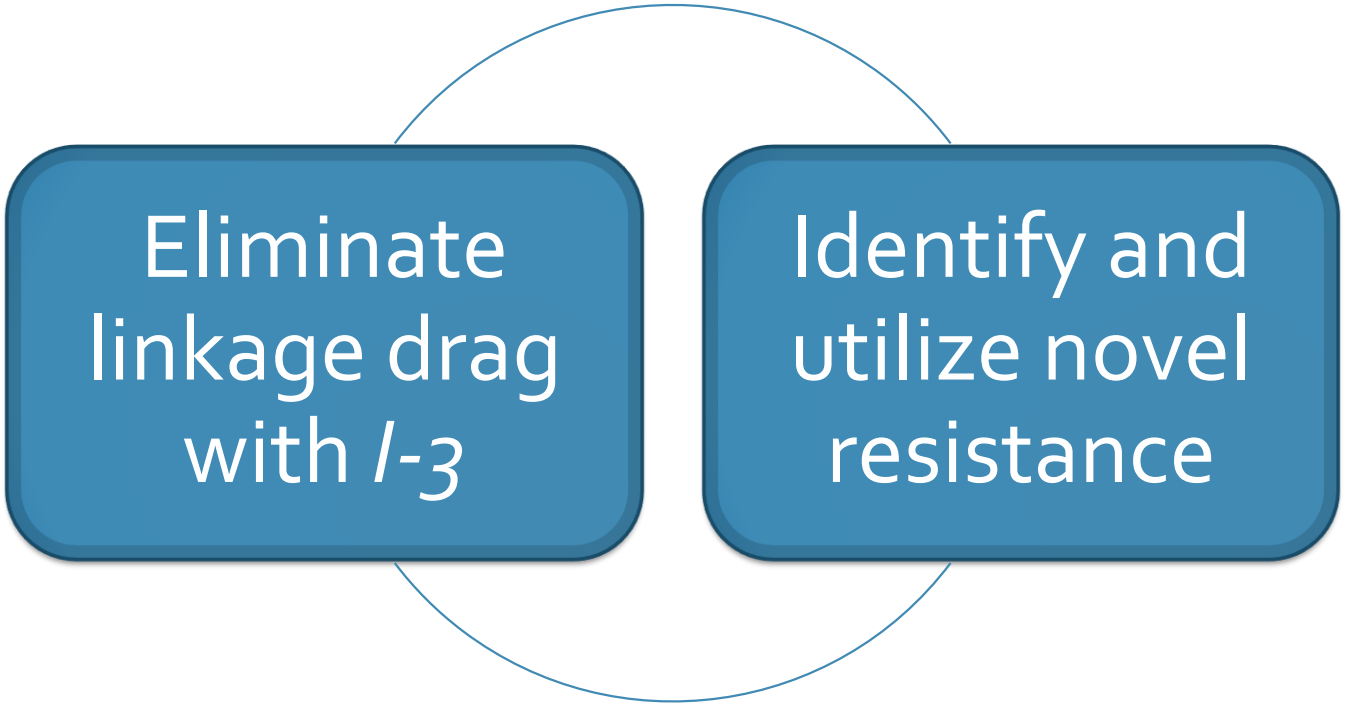
- **Linkage drag or pleiotropy?**



Approach


Eliminate linkage drag with *l-3*
Identify and utilize novel resistance

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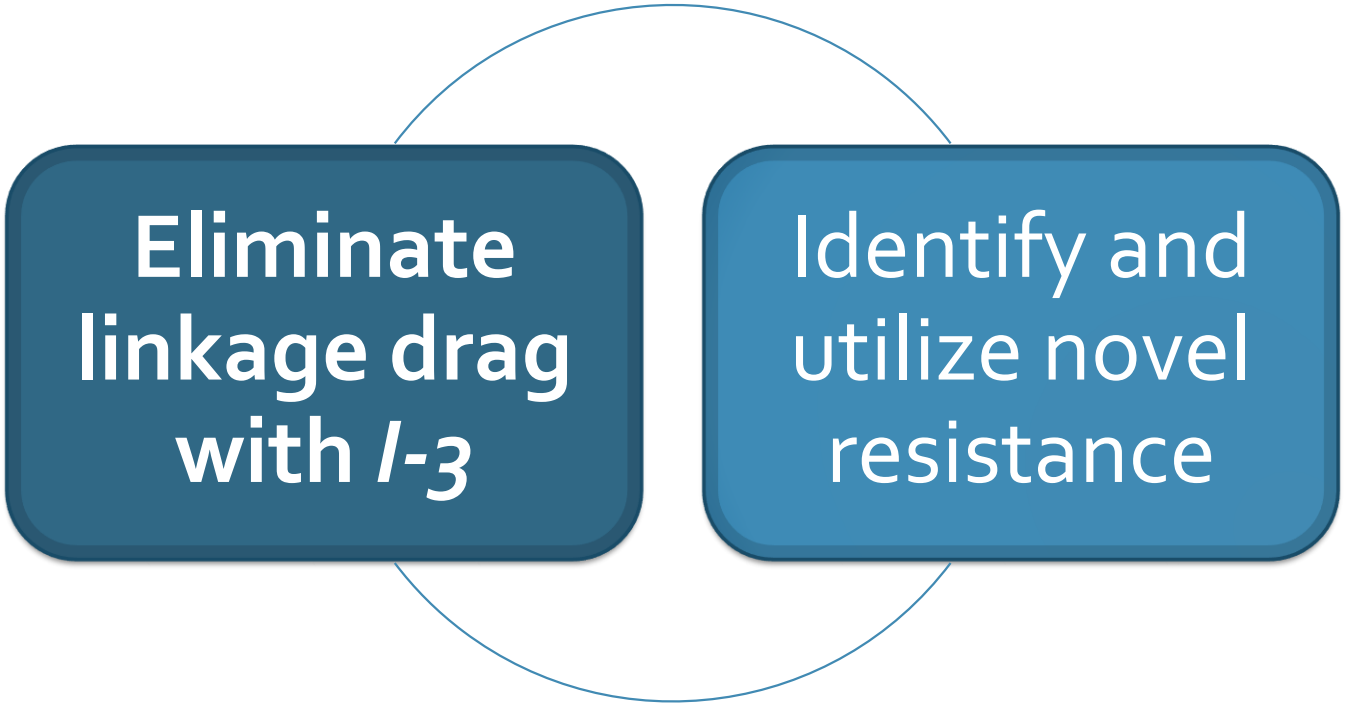
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Linkage drag

- Linkage drag or pleiotropy?
  - Pleiotropy – *I-3* itself
  - **Linkage drag – linked genes from wild species**

Theor Appl Genet (2018) 131:145–155
https://doi.org/10.1007/s00122-017-2991-4

CrossMark

ORIGINAL ARTICLE

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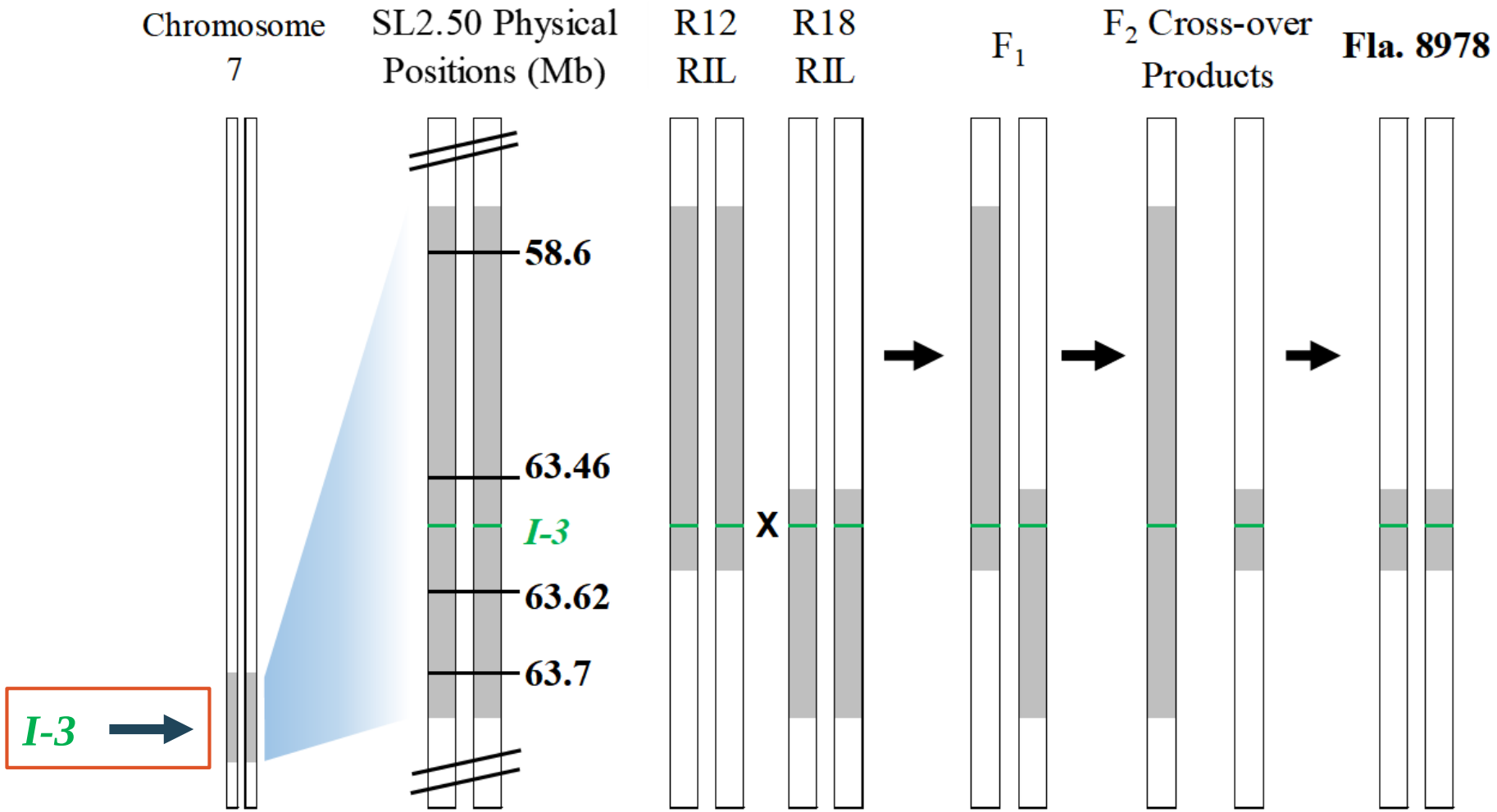
Abstract

Key message **The negative association between the *I-3* gene and increased sensitivity to bacterial spot is due to linkage drag (not pleiotropy) and may be remedied by reducing the introgression size.**

Eliminate linkage drag



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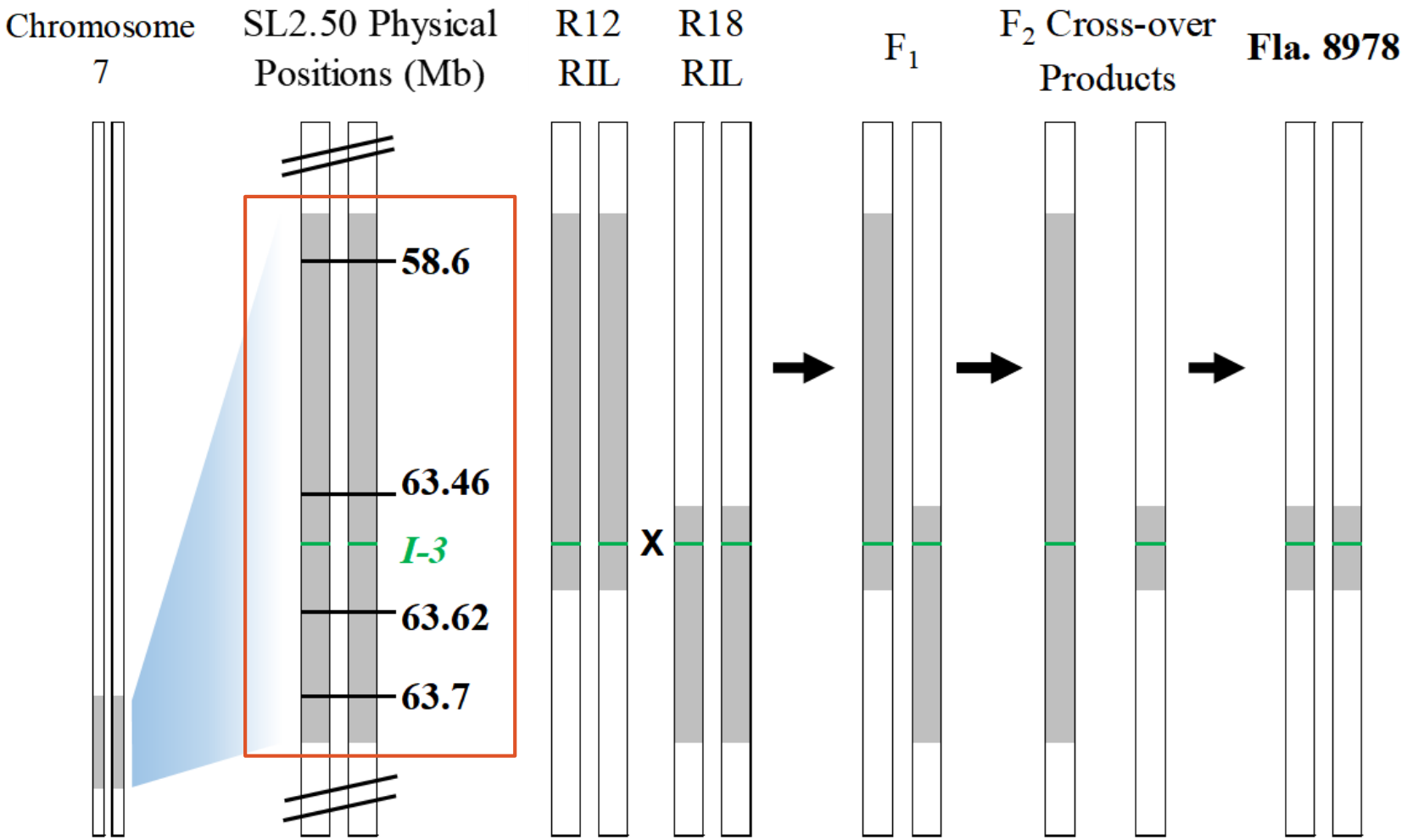

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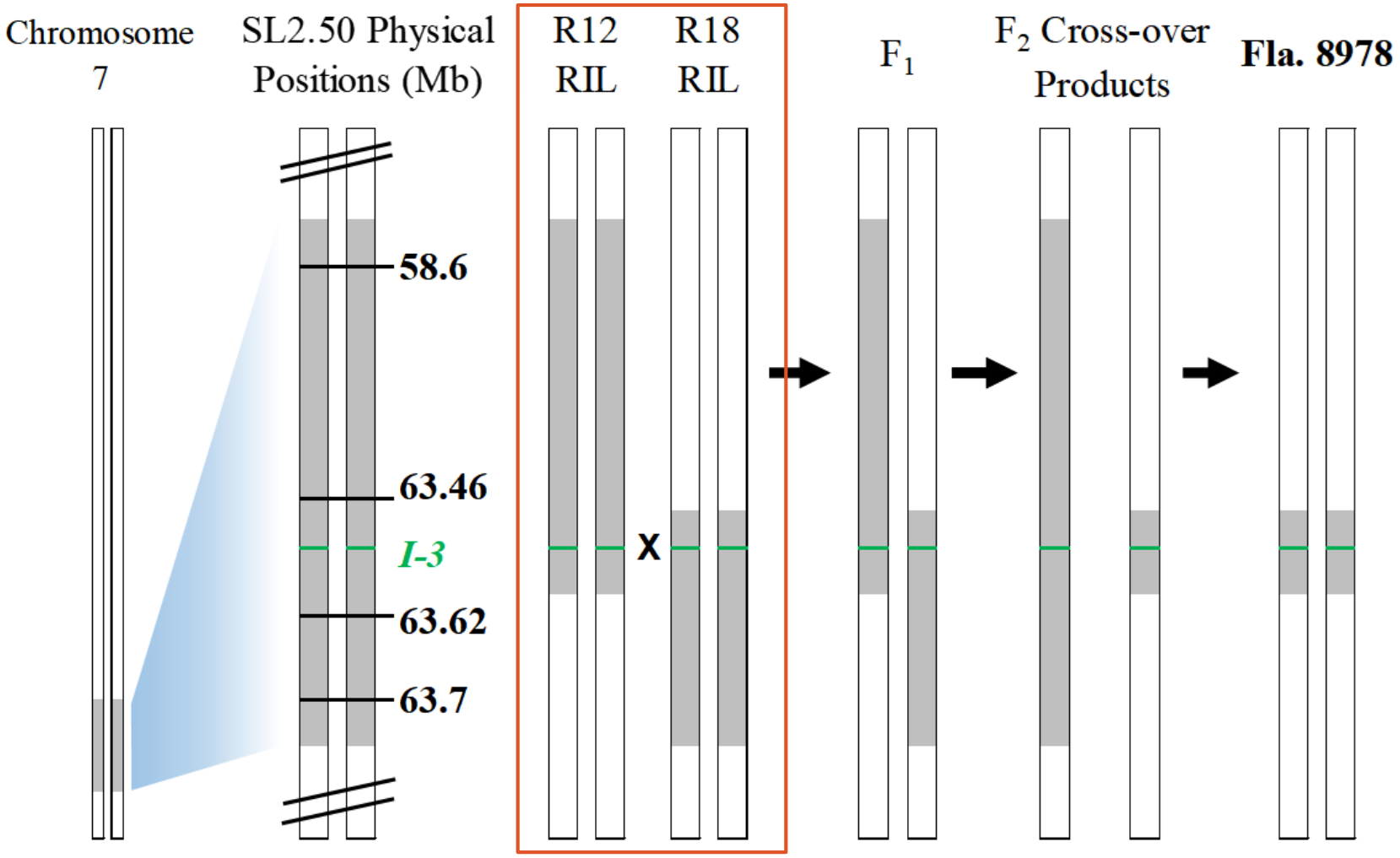

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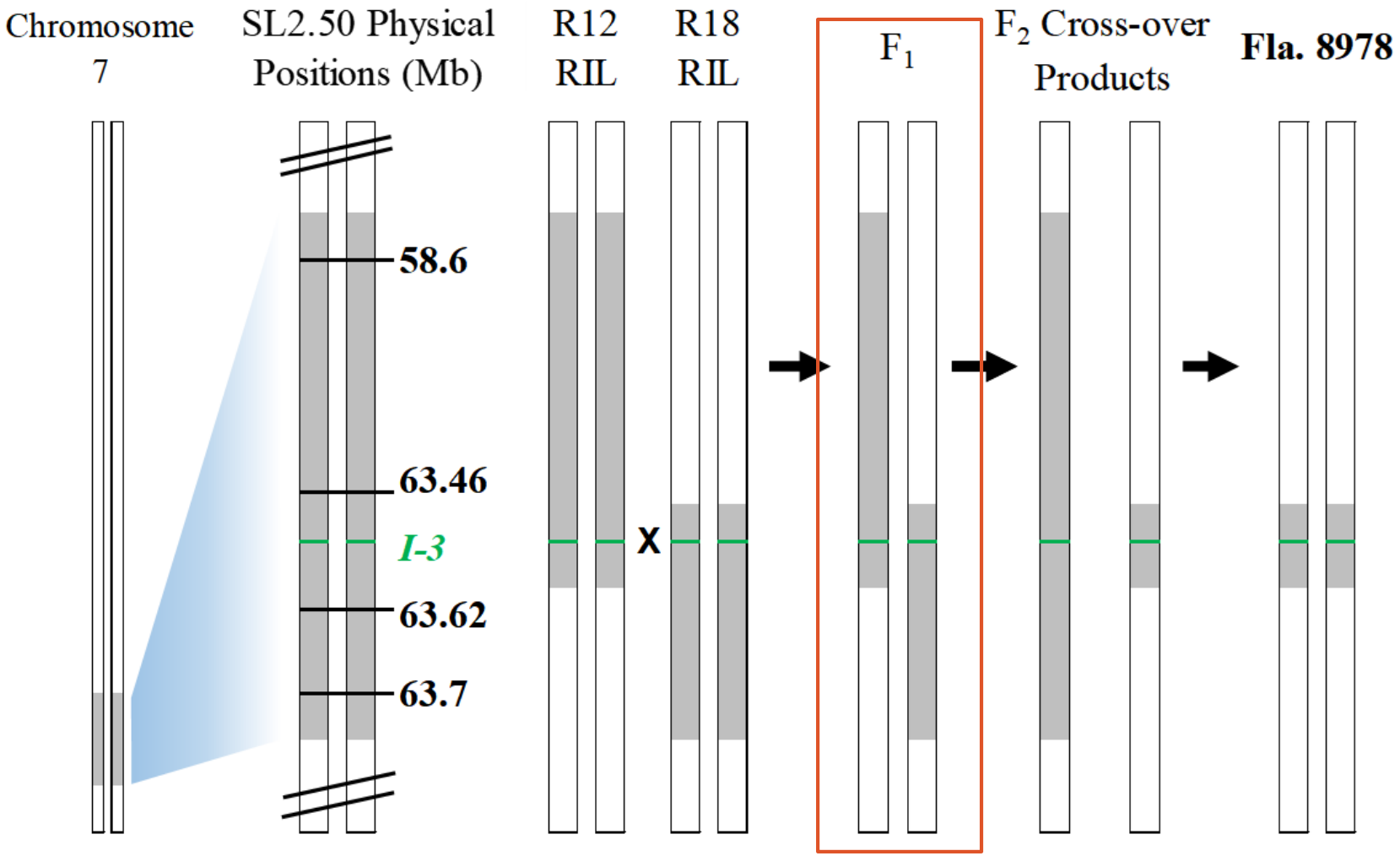

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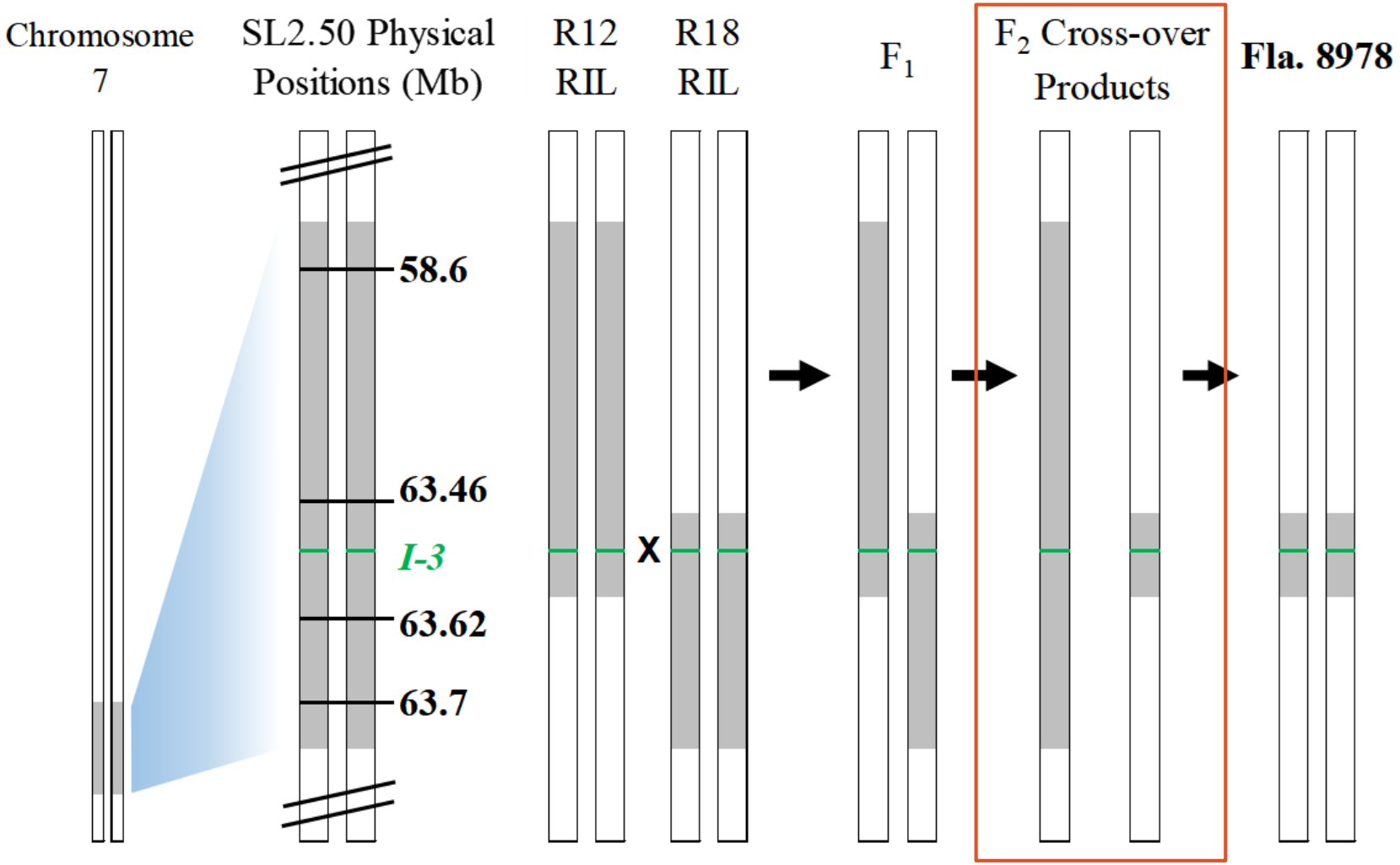

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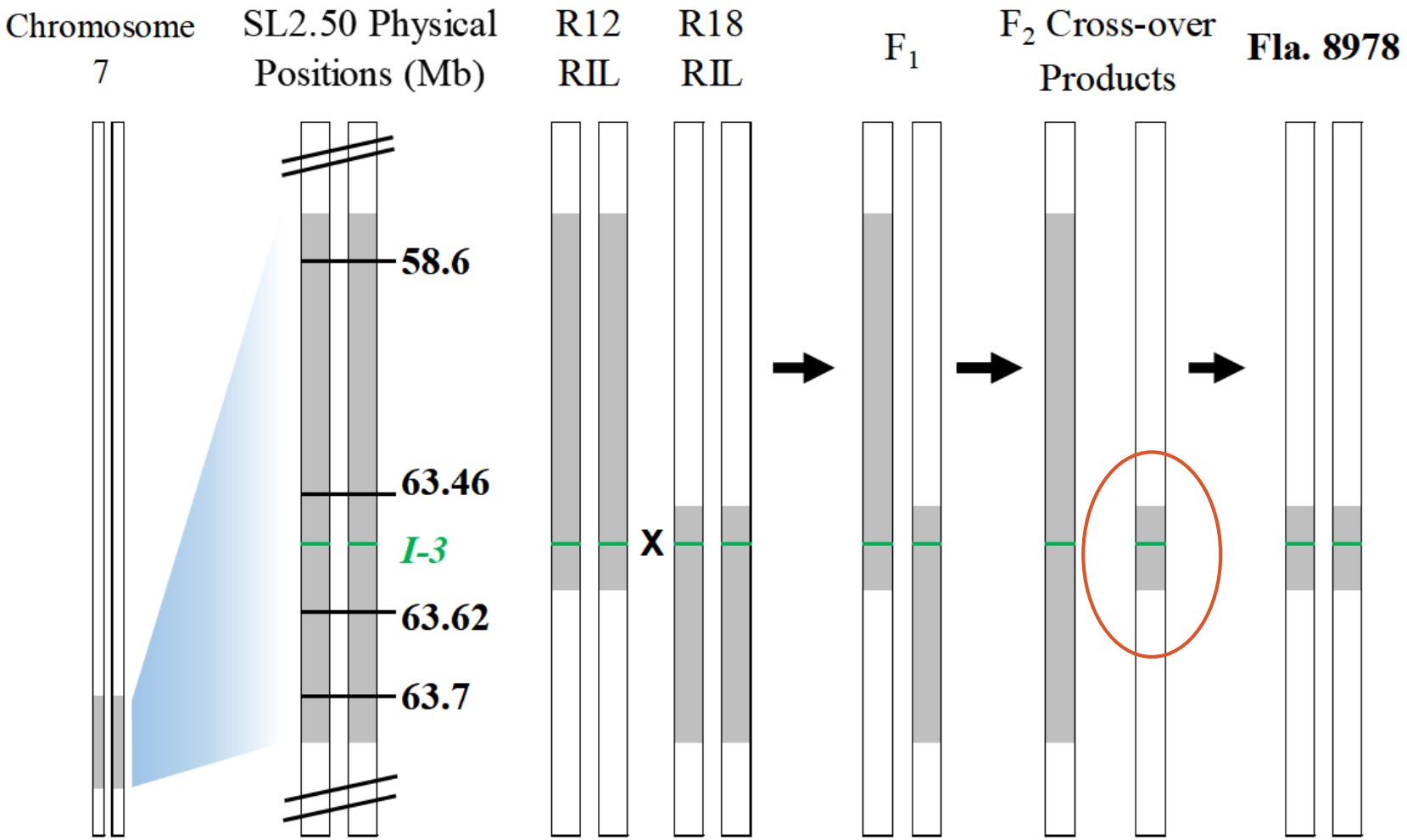

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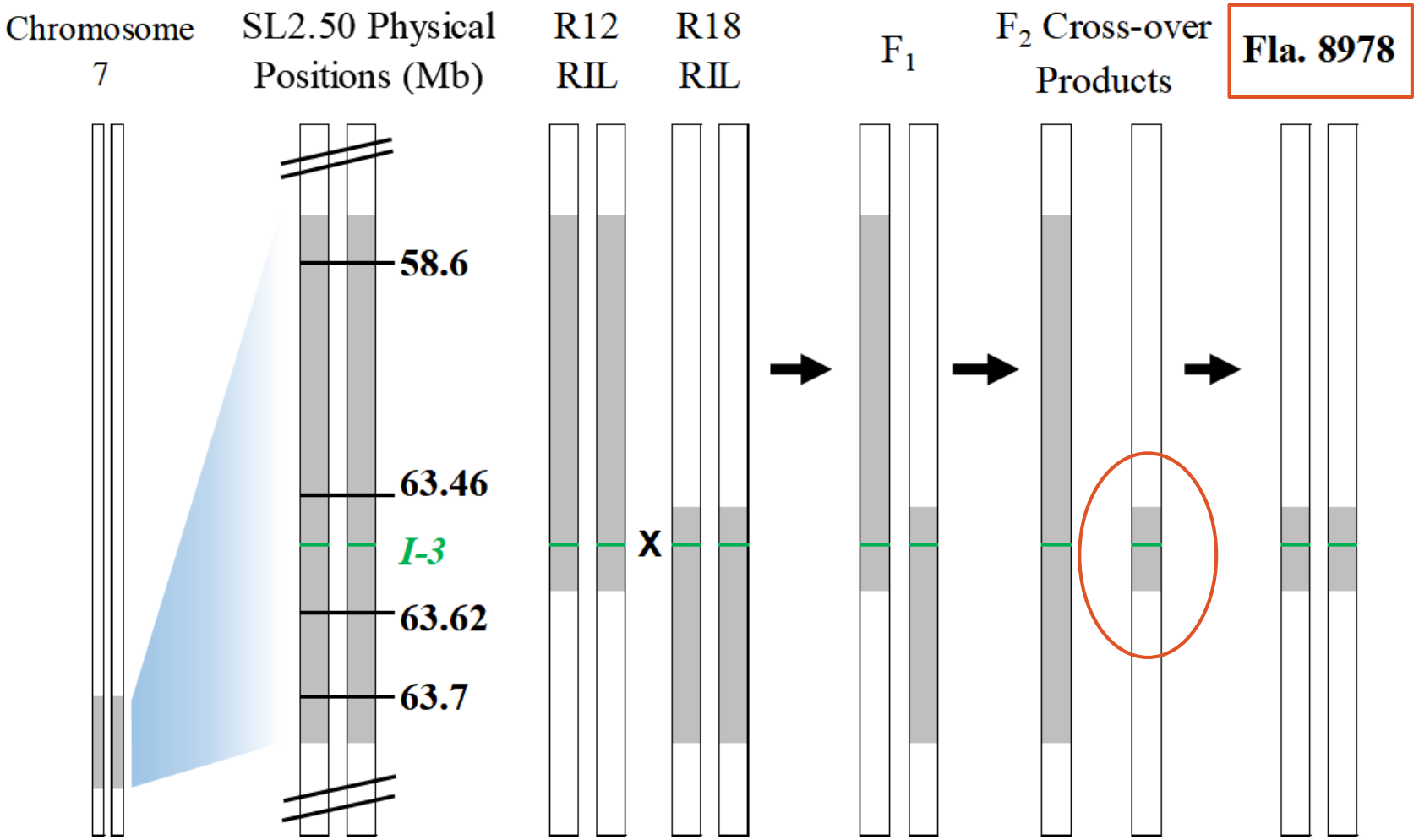

Eliminate linkage drag

- Backcrossing this minimal introgression into several elite UF/IFAS breeding lines
- Testing for effect on bacterial spot sensitivity and fruit size

Genotype	Introgression
Fla. 7946	Lg/Lg Lg/Min Min/Min
Fla. 8059	-/- Min/- Min/Min

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Genotype	Introgression	Bacterial Spot Rating	Average Fruit Size (g)
Fla. 7946	Lg/Lg	5.8 A	132 A
	Lg/Min	5.6 AB	149 AB
	Min/Min	5.2 BC	154 BC
Fla. 8059	-/-	4.8	111
	Min/-	4.9	110
	Min/Min	4.8	115

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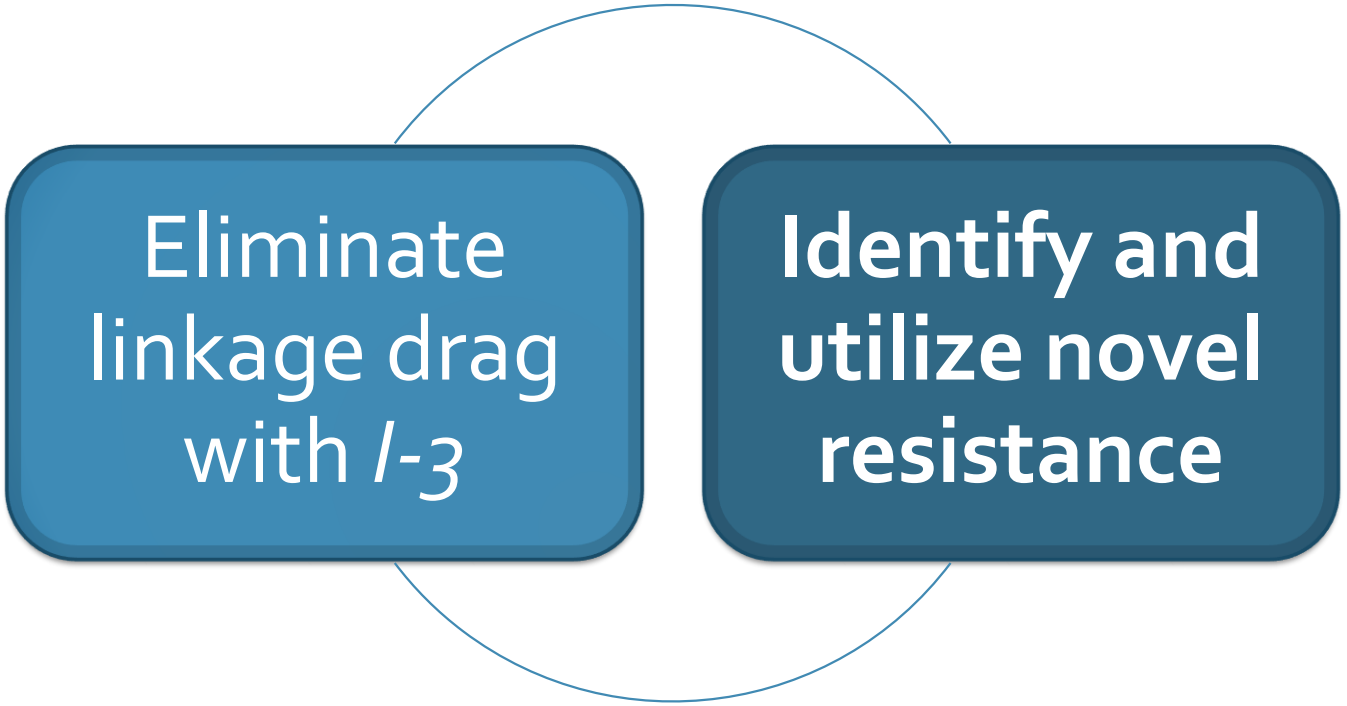
Linkage with negative effects likely broken.

Approach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Identify and utilize novel resistance

Novel *Fol3* resistance

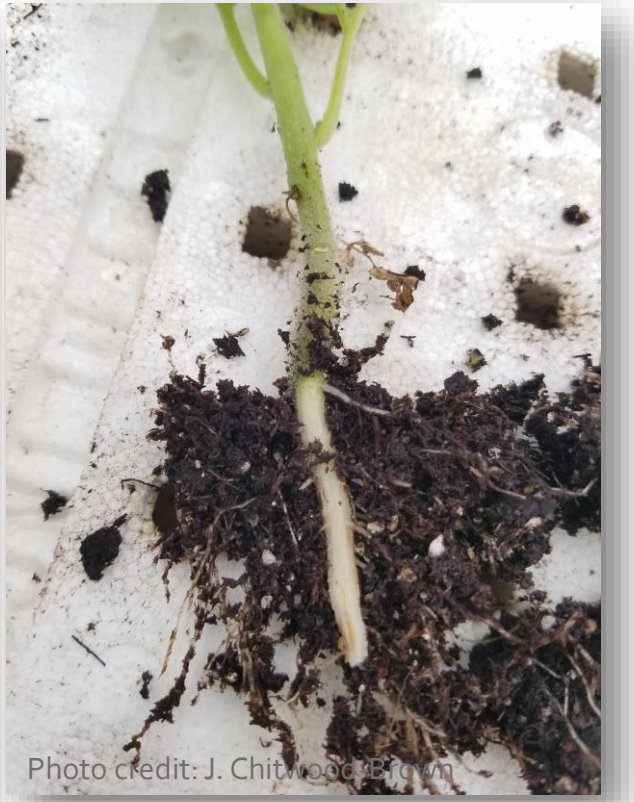
- *S. pennellii* demonstrated to have high resistance to fusarium wilt
- 42 *S. pennellii* accessions from the Tomato Genetic Resource Center (TGRC)
  - Almost all accessions resistant
- Resistance introgressed into Florida breeding lines via backcrossing
  - Seedling disease assays, selecting for resistance


Photo credit: J. Li


Photo credit: J. Chitwood-Brown

Novel *Fol3* resistance

- Molecular markers used to select away from known resistance genes
- Spring 2018 - resistance from 26 accessions advanced to BC5F1
- Choosing families for mapping
  - Clear phenotypes
  - Segregation ratios
  - Phylogenetic relationships

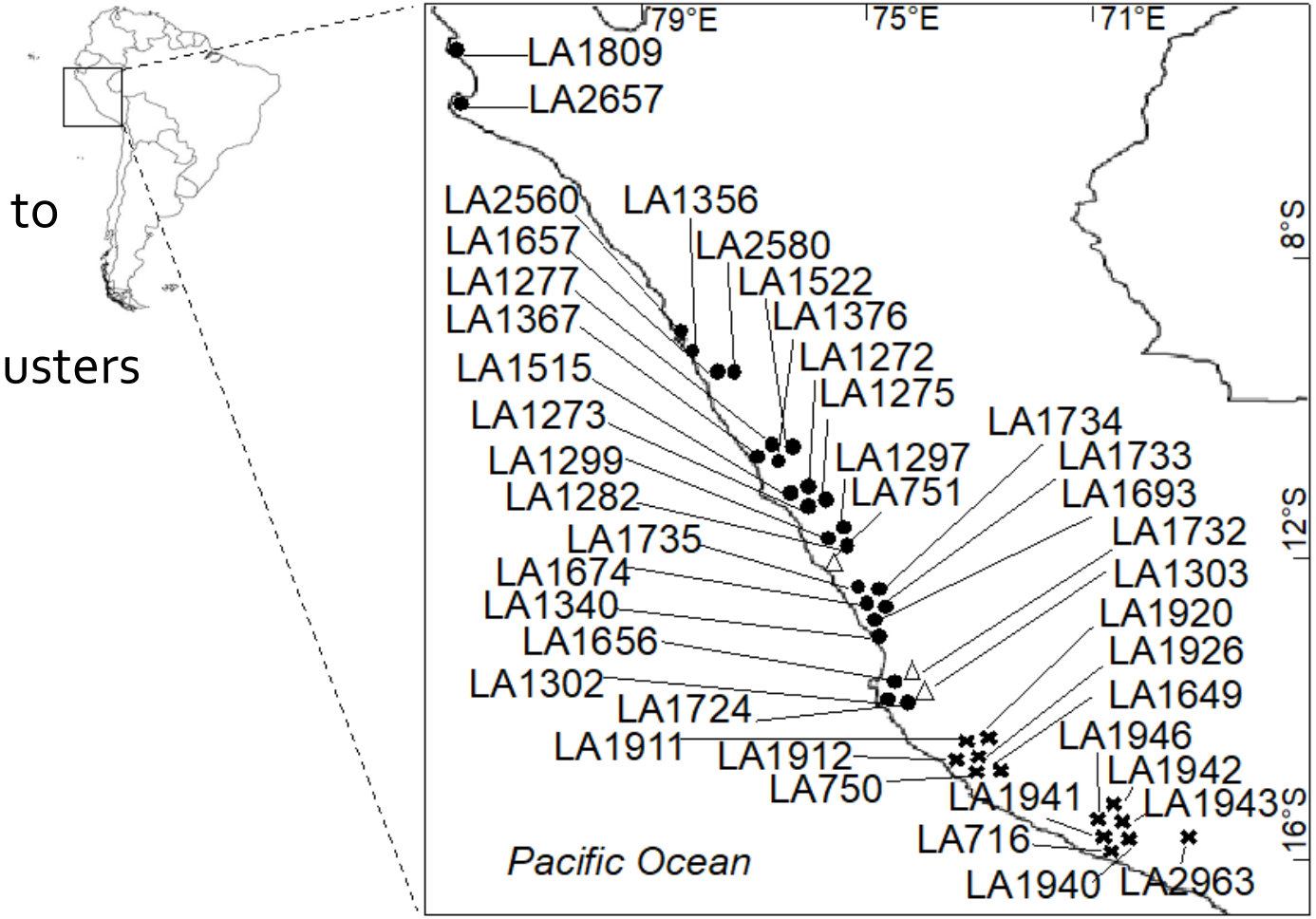


Novel *Fol3* resistance

Resistance from	Healthy	Infected	Ratio
LA750	45	7	6:1
LA1273	43	12	4:1
LA1302	33	13	3:1
LA1303	42	13	3:1
LA1522	43	13	3:1
LA1809	37	15	3:1
LA1911	44	12	4:1

Novel *Fol3* resistance

- Phylogenetic relationships
- Different accessions belong to different clusters
- Accessions from different clusters chosen



Credit: T.G. Lee

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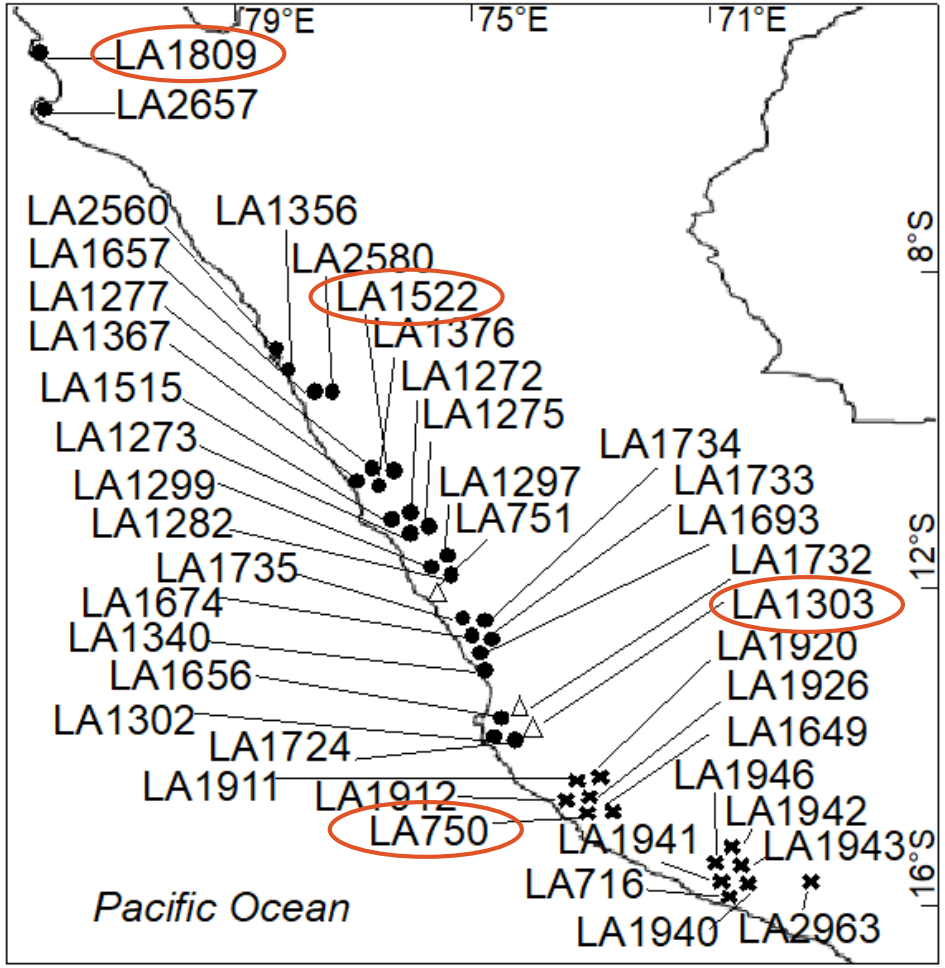


Credit: T.G. Lee

Families with resistance from these 4 accessions are being genotyped for mapping and prepared for **characterization studies**.

Impacts

Linkage between *I-3* and negative traits likely broken

Continued exploration of novel *Fol3* resistance alleles

Combine available and novel genes for more durable resistance


Photo credit: J. Chitwood-Brown


Photo credit: J. Chitwood-Brown

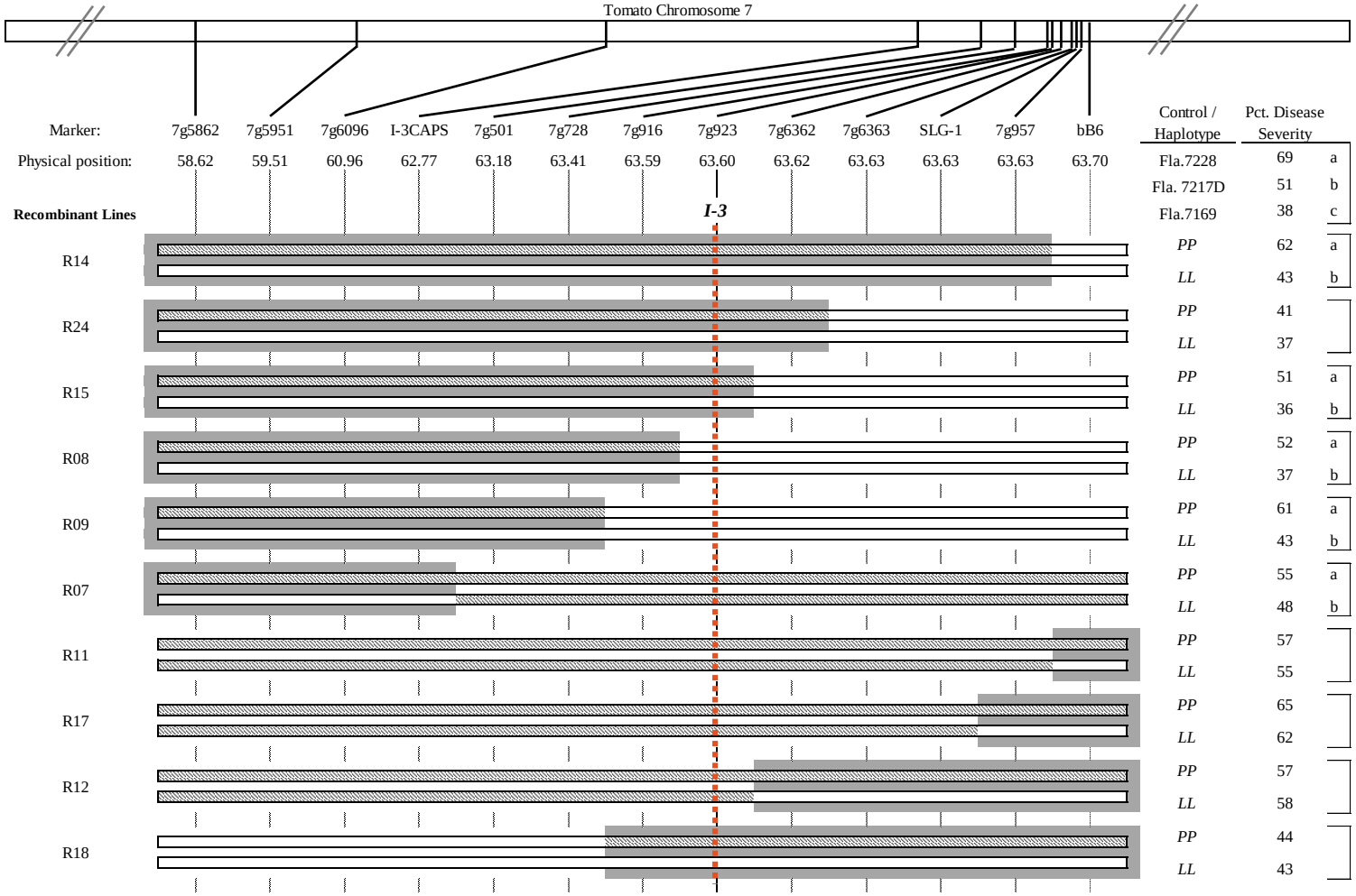

https://www.upi.com/Science_News/2015/08/19/Better-tasting-grocery-store-tomatoes-coming-soon-scientists-say/8301439994501/

Thank you

- Committee members
  - Dr. Sam Hutton – advisor
  - Dr. Tong Geon Lee
  - Dr. Gary Vallad – plant pathology lab
  - Dr. Vance Whitaker
- Tomato breeding lab
  - Rebecca Wente
  - Dolly, Jose, Judith, Kazuyo, Keri, Nate, Reza, Tim
  - John and Upinder
  - Edgar and Jasmine
- Funding
  - PBGI
  - USDA Tomato CGC

QUESTIONS?

Recombinant inbred lines



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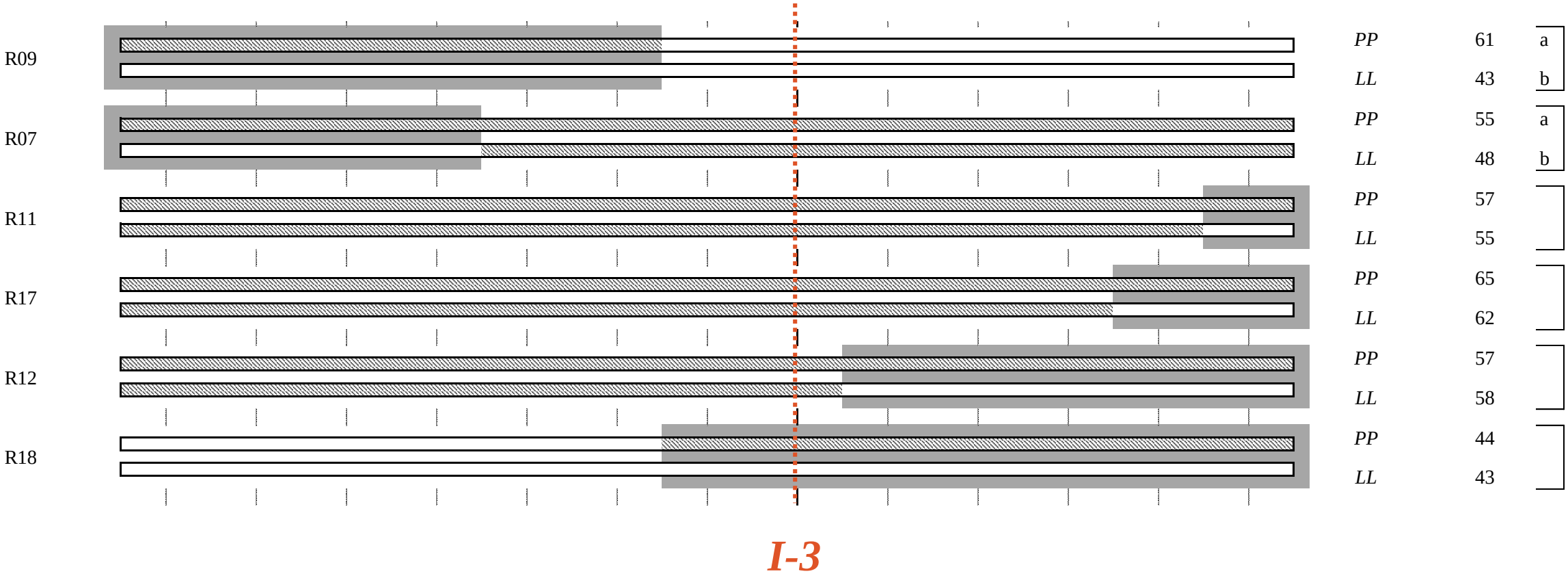

Horsfall-Barratt Scale

Score	% Diseased Tissue
1	0%
2	0-3%
3	3-6%
4	6-12%
5	12-25%
6	25-50%
7	50-75%
8	75-87%
9	87-94%
10	94-97%
11	97-100%
12	100%