Fresh Market Tomato Breeding at the University of Florida

J. W. Scott
Gulf Coast Research and Education Center
IFAS, University of Florida
14625 CR 672, Wimauma, FL 33598, USA
813-633-4135 jwsc@ufl.edu
http://tombreeding.ifas.ufl.edu/

COMPARING APPLES TO TOMATOES:
Is Tasti-Lee a new paradigm for tomatoes?

Are any of you TBRT people reading this??

John. (Jay) W. Scott
Gulf Coast Research & Education Center
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813-633-4135, jwsc@ufl.edu
http://tombreeding.ifas.ufl.edu/

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Tomato Varieties with Resistance to Viral and Bacterial Diseases

TBRT: I MAY TELL SOME JOKES BUT I DON'T REALLY CARE IF YOU LAUGH OR NOT

Dr. J. W. Scott

Gulf Coast Research & Education Center

14625 CR 672, Wimauma, FL 33598

813-633-4135 jwsc@ufl.edu http://tombreeding.ifas.ufl.edu

The Same Old Changes in Tomato Breeding at the University of Florida

DARUSH IS HAVING 2ND THOUGHTS ABOUT INVITING ME HERE

J. W. Scott
813-633-4135
jwsc@ufl.edu

http://tombreeding.ifas.ufl.edu/

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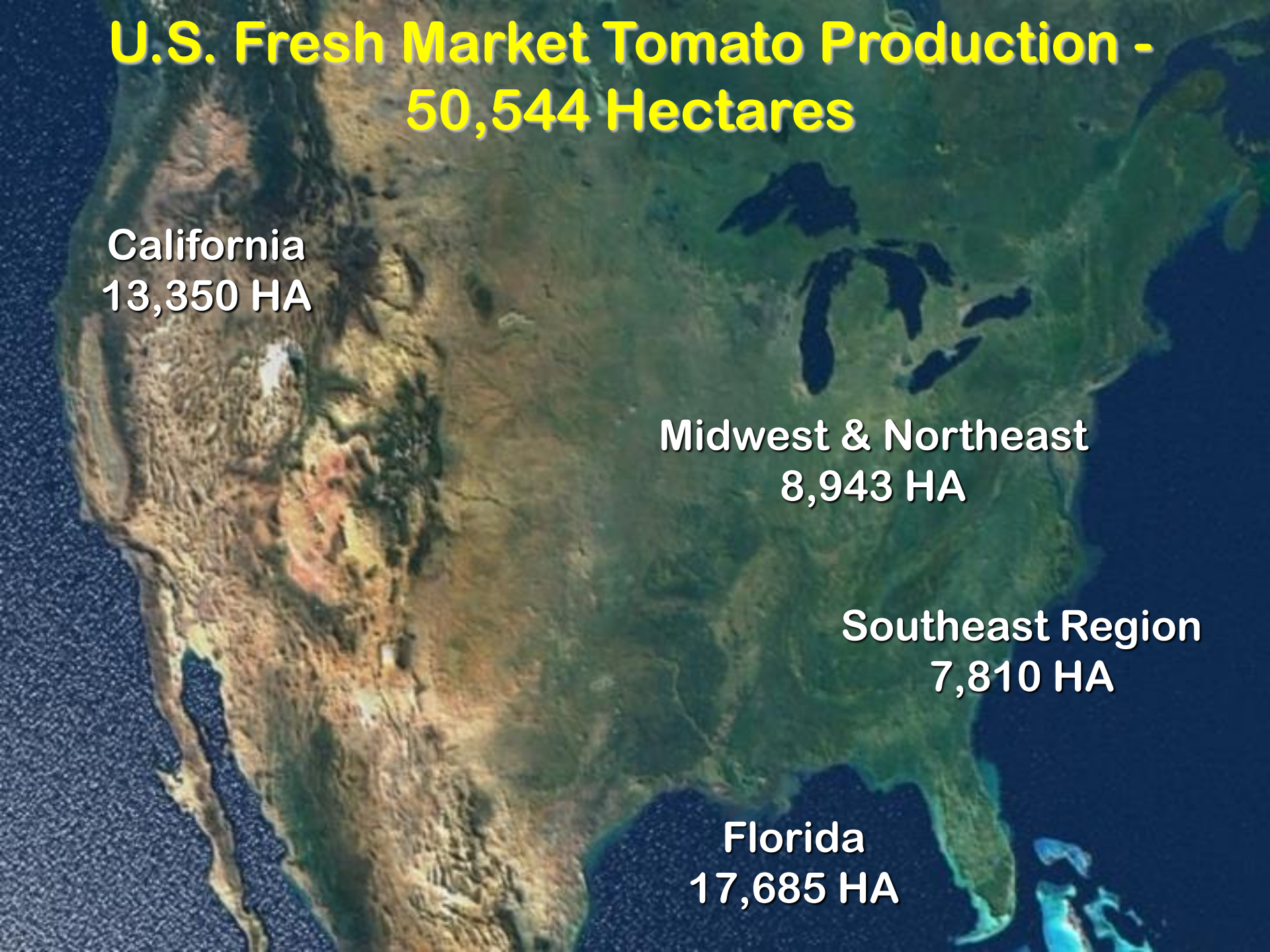
Approaches for Developing Bacterial Spot Resistant Tomato Cultivars

J.W. Scott, S.F. Hutton, D.F. Francis, S-C. Sim, and D.M. Horvath

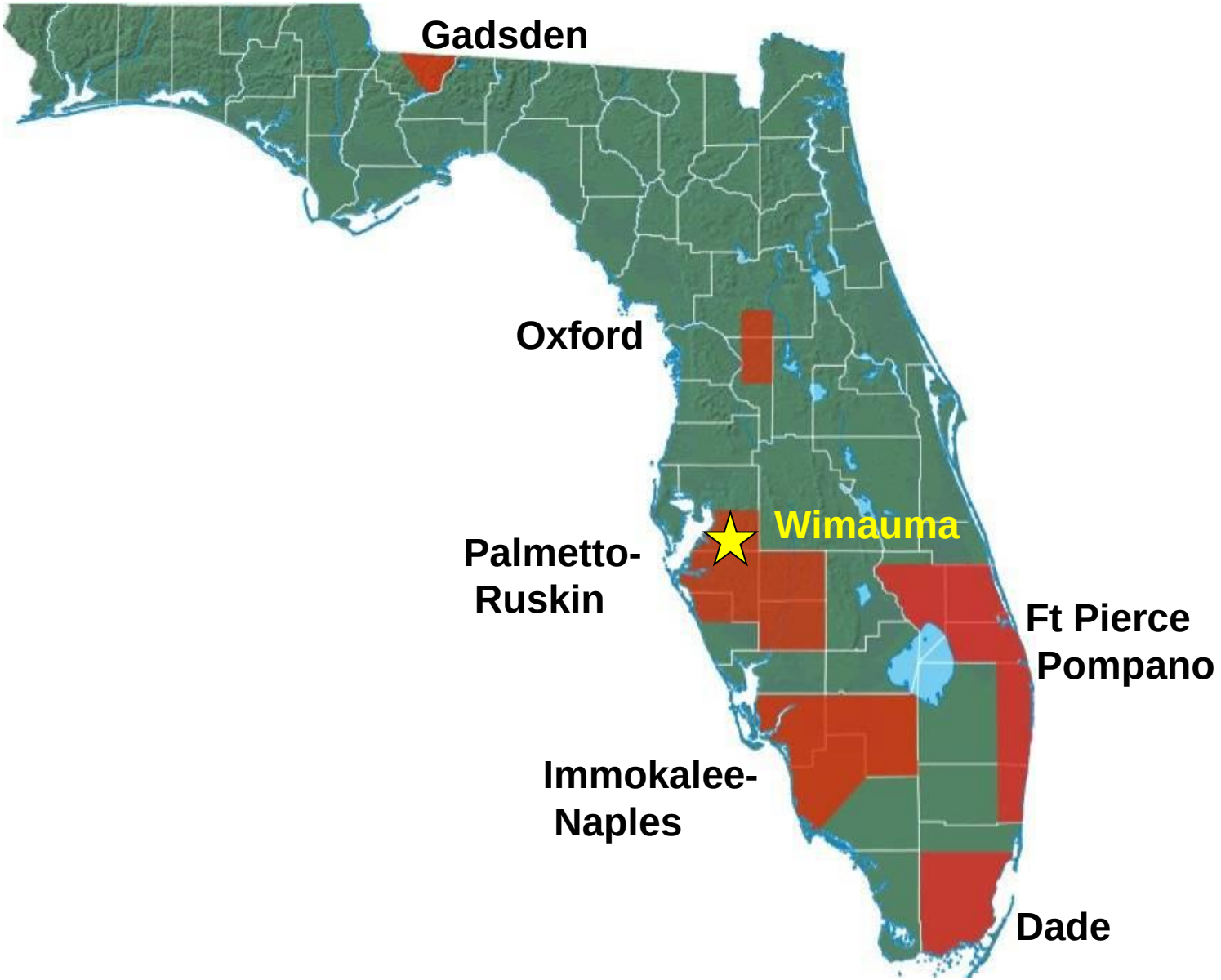
Gulf Coast Research & Education Center
14625 CR 672,
Wimauma, FL 33598
813-633-4135,
jwsc@ufl.edu
http://tombreeding.ifas.ufl.edu

UF UNIVERSITY of FLORIDA IFAS

U.S. Fresh Market Tomato Production - 50,544 Hectares



Florida
Principle Tomato Producing Areas



History of Bacterial Spot in Tomato

Xanthomonas euvesicatoria **race T1**

1989 *X. vesicatoria* **race T2**

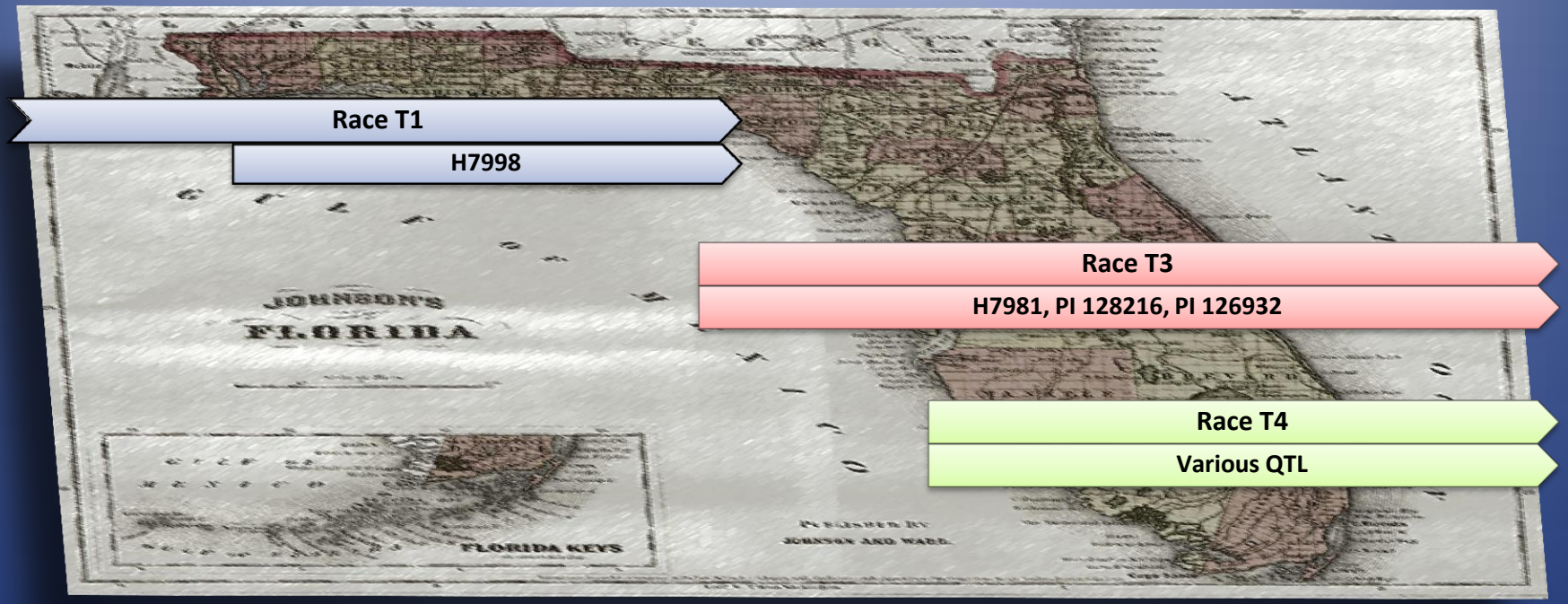
1991 *X. perforans* **race T3**

1998 *X. perforans* **race T4**

2002 *X. perforans* **race T5**

2009? *X. gardneri*

1980 — **1990** — **2000** — **2010**



Resistance sources:

Race T1
- H7998 (HR)
- PI 114490
- PI 155372

Race T2
- PI 114490
- PI 155372

Race T3
- H7981 (HR)
- PI 128216 (HR)
- PI 126932 (HR)
- PI 114490
- PI 155372
- LA 716 (HR)

Race T4
- PI 114490
- LA 716 (HR)


PI 114490

Correlation coefficients for bacterial spot disease severity ratings between races T1, T2, and T3 in Summer 1998 and 1999 for PI 114490 and T2 or T3 selected lines derived from PI 114490.

	Race/year				
Race/year	**T1/1998**	**T2/1998**	**T3/1998**	**T1/1999**	**T2/1999**
T2/1998	0.90 *** [z]	-	-	-	-
T3/1998	0.24 ns	0.10 ns	-	-	-
T1/1999	0.70 **	0.80 ***	0.04 ns	-	-
T2/1999	0.86 ***	0.92 ***	0.23 ns	0.82 ***	-
T3/1999	0.36 ns	0.27 ns	0.63 *	-0.01 ns	0.16 ns

[z] ***=significant at P=0.0001; **=significant at P=0.01; *=significant at P= 0.05; and ns=not significant.

Bacterial Spot Resistance From PI 114490-2000

1) Good resistance to T1 & T2, only fair for T3

2) Resistance to T1 and T2 closely related, not so close for T3

3) Resistance controlled by 2-3 genes probably

4) Resistance to T4 unknown


BREAK.com

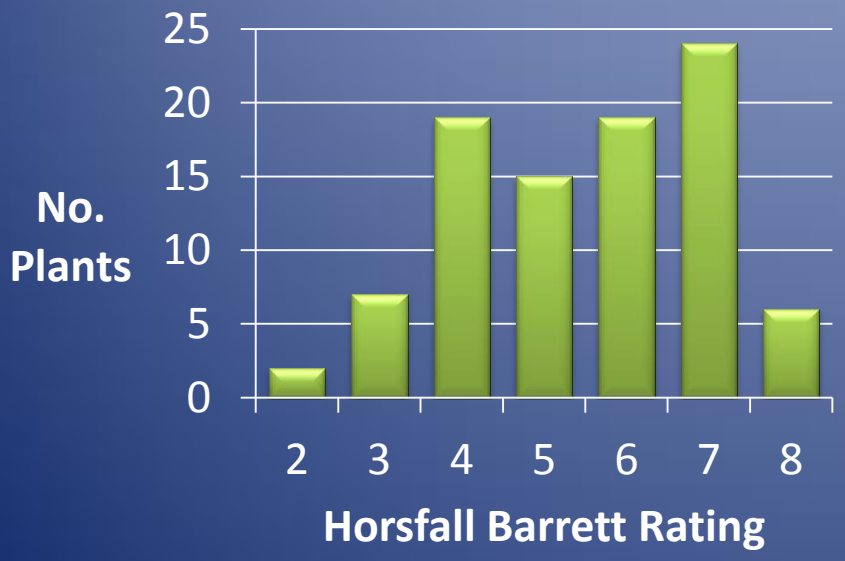
Materials and Methods

- PI 114490
  - Highly resistant
  - Race non-specific
  - Quantitative
  - QTL on chromosomes 3 and 11
    (Hutton et al., 2010)
- Susceptible parents
  - Fla. 7324 and Fla. 7613
- Selective phenotyping
  - *sp* and QTL 11
  - 500 F_2 progeny
- Field evaluations-T4 unless indicated
  - Fall 2010 (F2)
  - Spring 2011 (F3)
  - Fall 2011 (F4)
  - Spring 2012 (F5)
  - Summer 2012-races T1,T2,T3,Xg (Ohio)
- Selective genotyping
  - SolCAP/Illumina Infinium snp array

Materials and Methods

Phenotyping Results:

92 selections



Genotyping Results:

7720 total polymorphic markers

2689 p.m. in Fla. 7324 pop

2488 p.m. in Fla. 7613 pop

2248 p.m. in both populations

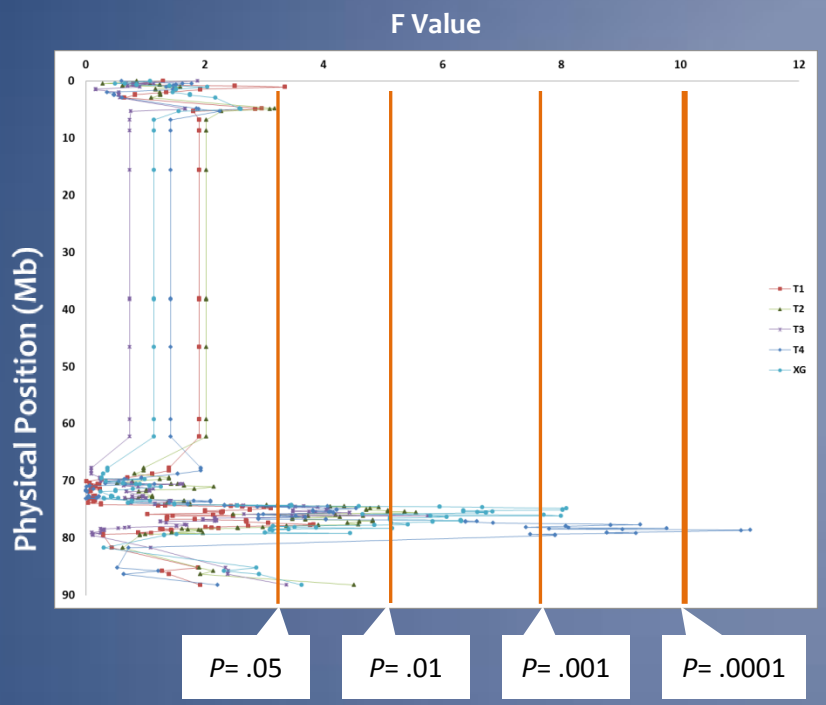
2228 known physical locations

Single Marker Analysis

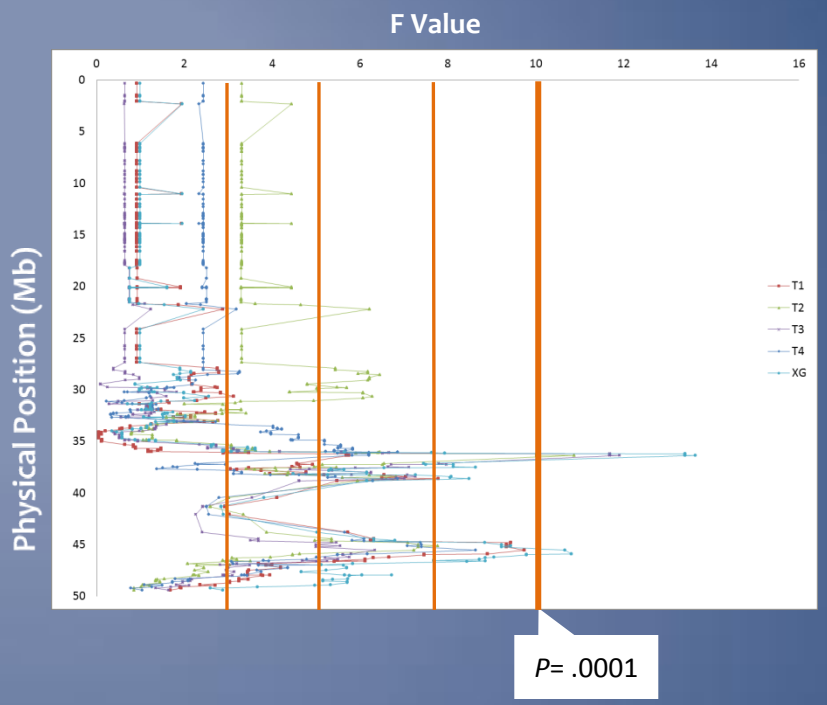
GLM (SAS)

We acknowledge Illumina's technology and USDA-NIFA Agriculture and Food Research Initiative (AFRI) sponsored Solanaceae Coordinated Agricultural Project (SolCAP) for the data presented on the following set of slides

Chromosome 1



Chromosome 2



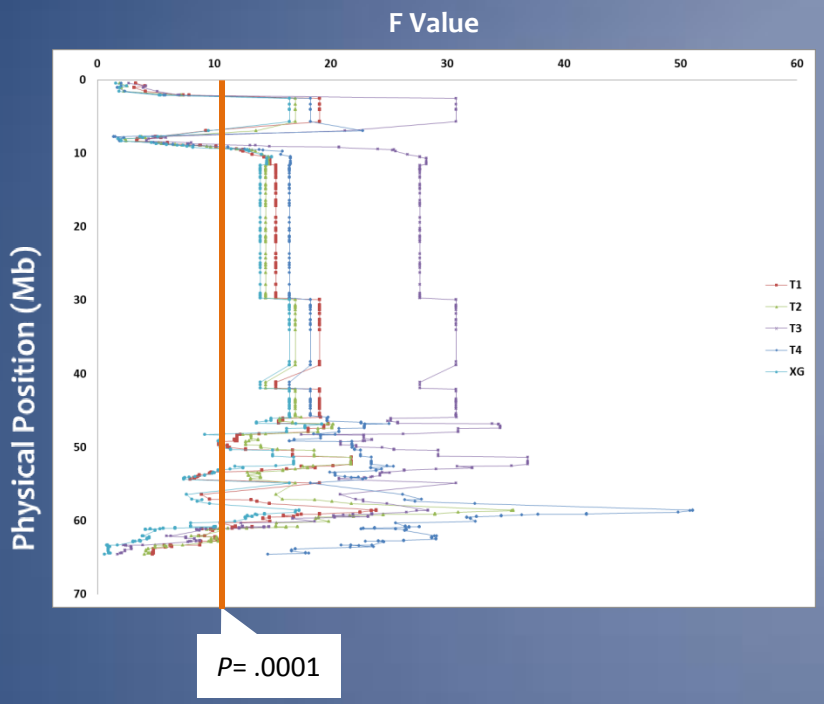
One region:

- T1 <0.05 - -
- T2 <0.01 - -
- T3 <0.01 -
- T4 <0.0001 - - - -
- Xg <0.001 - - -

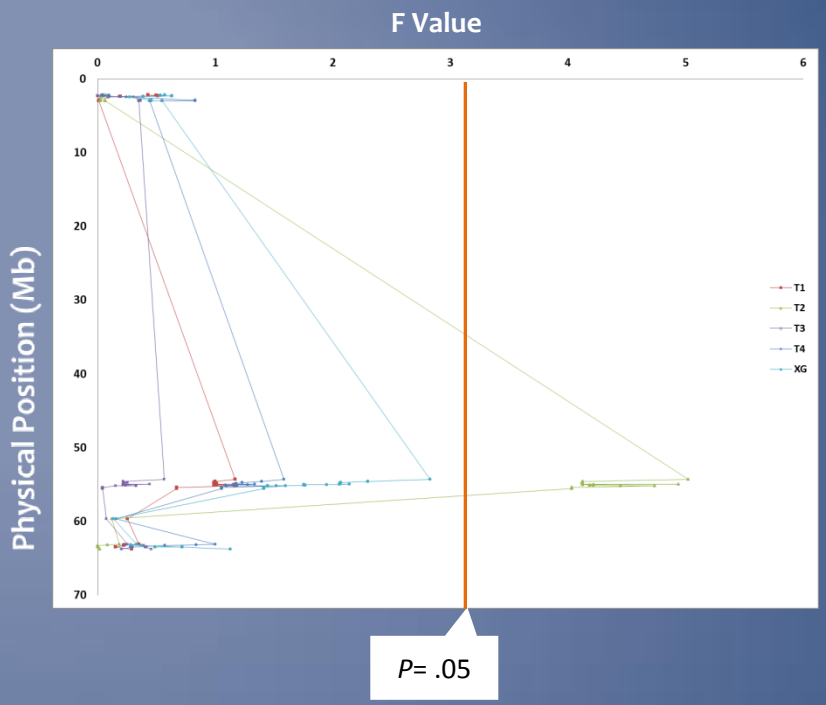
Two regions:

- T1 <0.05 + <0.001 +++++
- T2 <0.0001 ++ <0.001 +++
- T3 <0.0001 ++ <0.01 ++++
- T4 <0.01 +++ <0.001 ++++
- Xg <0.0001 ++ <0.0001 +++++

Chromosome 3



Chromosome 4



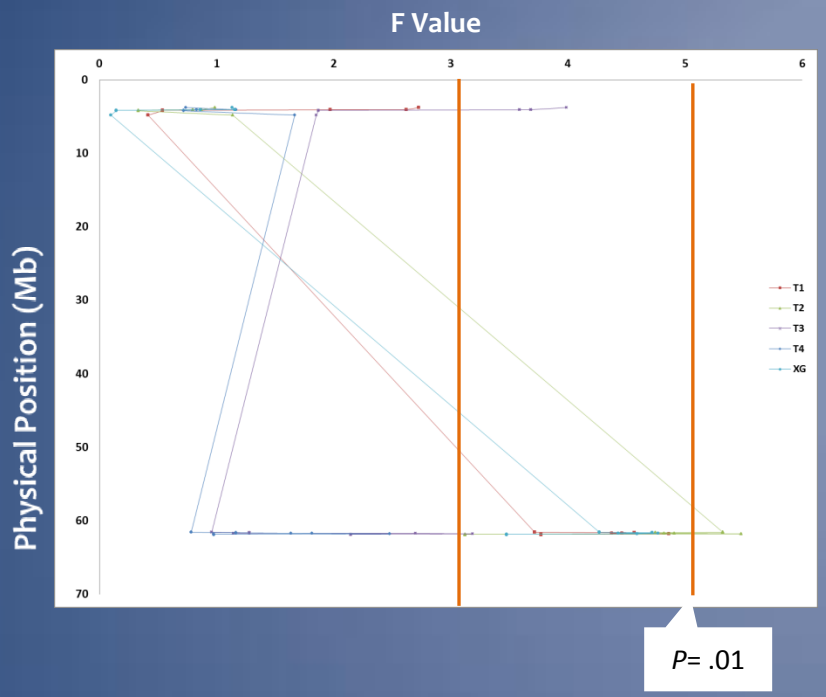
Major QTL:

- T1 <0.0001 ++++++
- T2 <0.0001 ++++++
- T3 <0.0001 ++++++++
- T4 <0.0001 ++++++++
- Xg <0.0001 ++++++

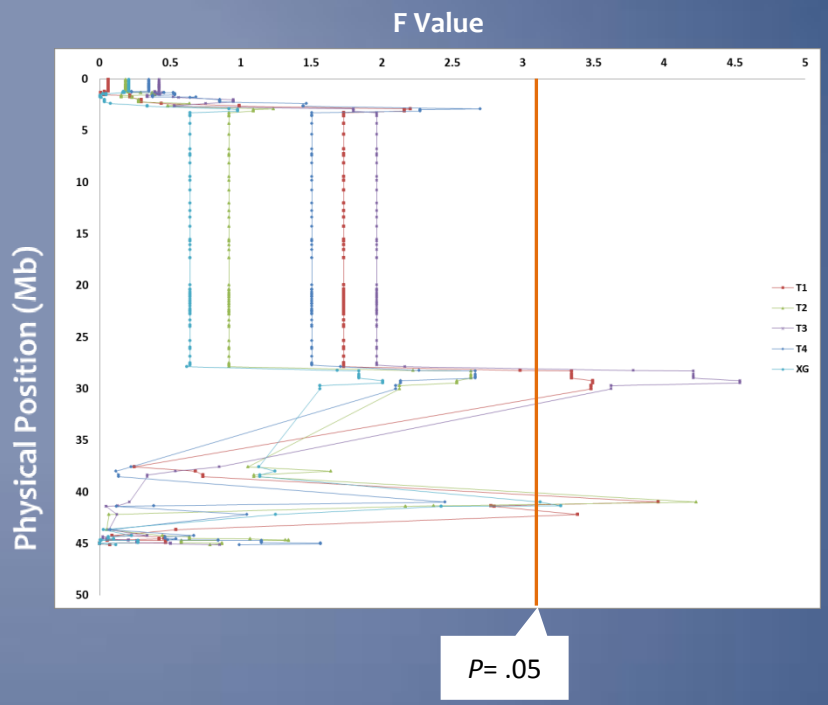
Minor region:

- T1
- T2 <0.05 - - -
- T3
- T4
- Xg

Chromosome 5



Chromosome 6



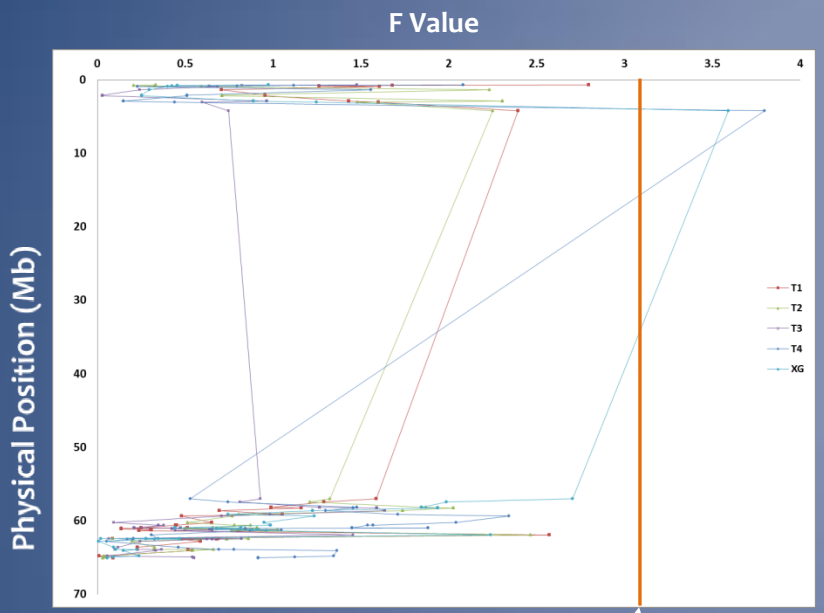
Minor effect:

- *T1 <0.05 ++*
- *T2 <0.01 ++++*
- *T3 <0.05 +*
- *T4*
- *Xg <0.05 +*

Two regions:

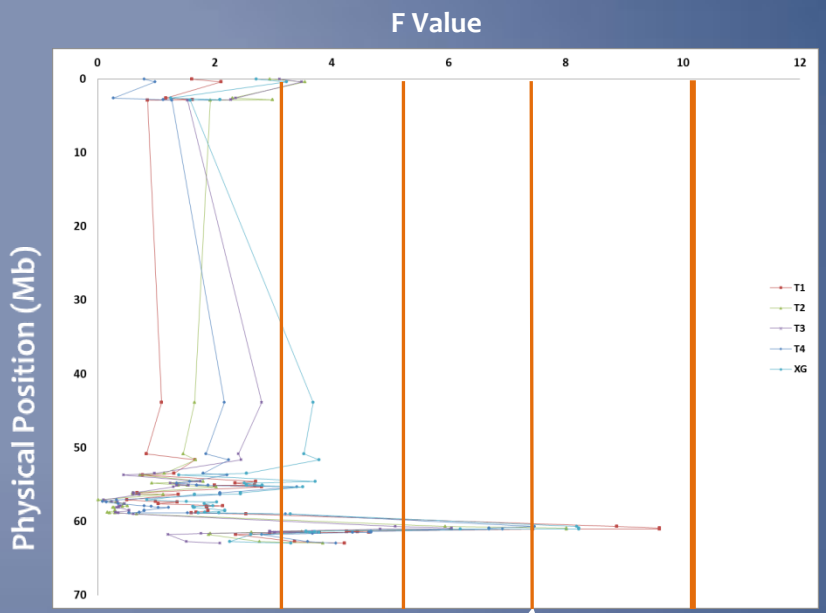
- *T1 <0.05 - <0.05 ++++++++*
- *T2 <0.05 +++++*
- *T3 <0.05 - -*
- *T4*
- *Xg <0.05 ++++++*

Chromosome 7



P= .05

Chromosome 8



P= .001

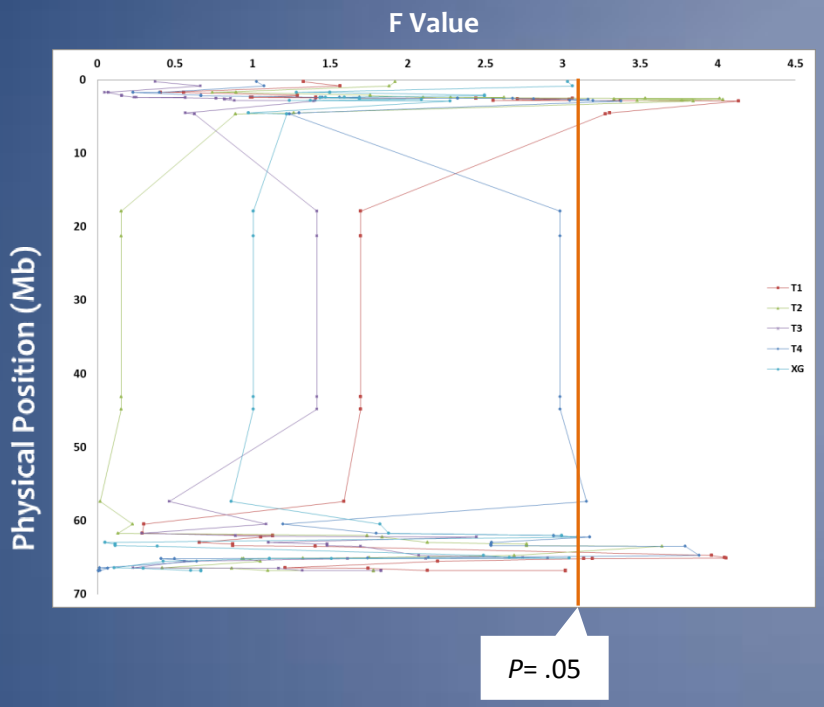
Minor effect:

- *T1*
- *T2*
- *T3*
- *T4 <0.05 - - -*
- *Xg <0.05 - - -*

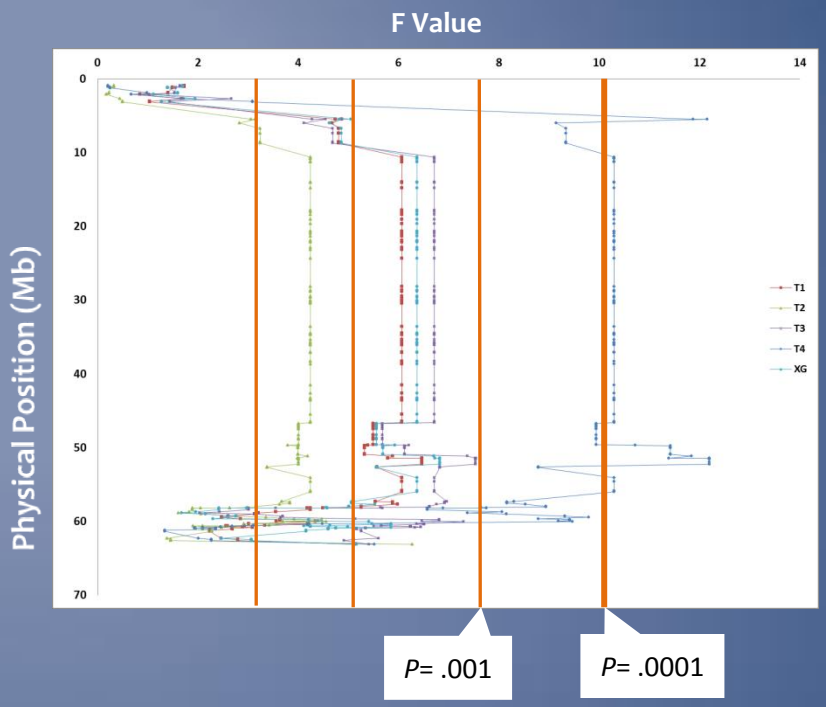
One region:

- T1 <0.001 ++
- T2 <0.001 ++
- T3 <0.01 +
- T4 <0.01 ++
- Xg <0.001 ++

Chromosome 9



Chromosome 10



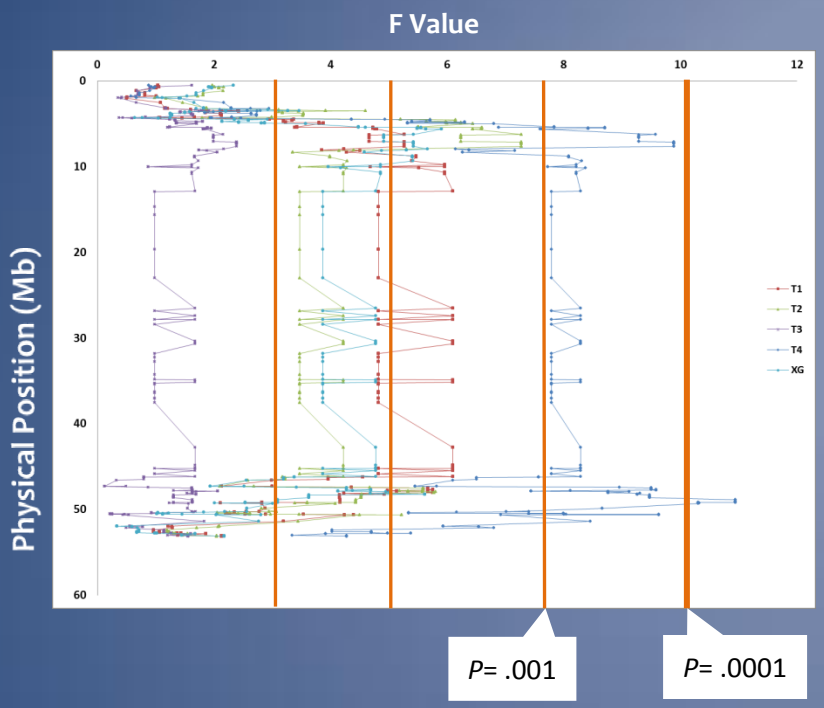
Two minor effects:

- T1 <0.05 - - - - <0.05 +++
- T2 <0.05 - - <0.05 ++
- T3
- T4 <0.05 - - - <0.05 +++
- Xg

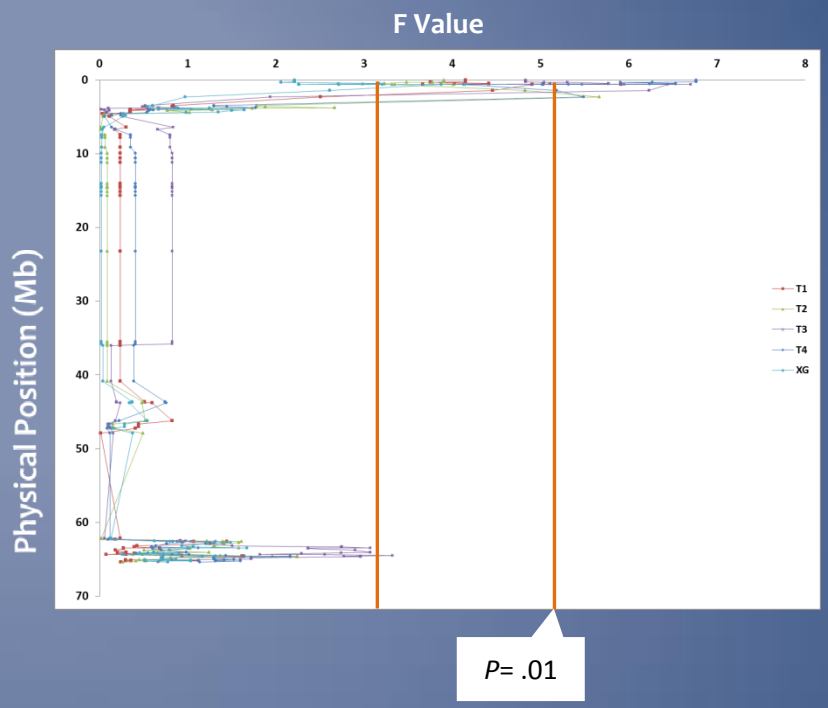
Two major regions:

- T1 <0.01 ++++ <0.01 ++++
- T2 <0.05 ++ <0.05 ++
- T3 <0.01 ++++ <0.01 +++
- T4 <0.0001 +++++ <0.0001 +++++
- Xg <0.01 ++++ <0.01 ++++

Chromosome 11



Chromosome 12



Two regions:

- T1 <0.01 +++ <0.01 ++
- T2 <0.05 +++ <0.05 ++
- T3
- T4 <0.001 ++++ <0.001 +++
- Xg <0.05 + <0.05 +

Minor effect:

- T1 <0.01 +++
- T2 <0.01 ++
- T3 <0.01 ++++
- T4 <0.01 ++++
- Xg <0.05 ++

PI 114490 QTL Summary

Strong Effects- 7 possible QTL

- Ch. 2: 2 regions all loci
- Ch. 3: large introgression all loci
- Ch. 10: 2 regions > for T4
- Ch. 11: 2 regions > for T4, nothing for T3

Weak Effects- 5 possible QTL

- Ch. 5: T2 mainly, no T4
- Ch. 6: T1, T2, Xg only
- Ch. 8: all races
- Ch. 9: T1, T2, T4
- Ch. 12: all races

Negative Effects- 5 possible QTL

- Ch. 1: >T4 but all races
- Ch. 4: T2 only
- Ch. 6: T3, T1
- Ch. 7: T4, Xg
- Ch. 9: T1, T2, T4

PI 114490 QTL Summary #2

- ✓ Validation Experiments Need to be Done:
- ✓ Which QTL Complement Each Other?
- ✓ Is There Linkage Drag?
- ✓ Thus, Much Work Remains but We Have Some Tools to Work With

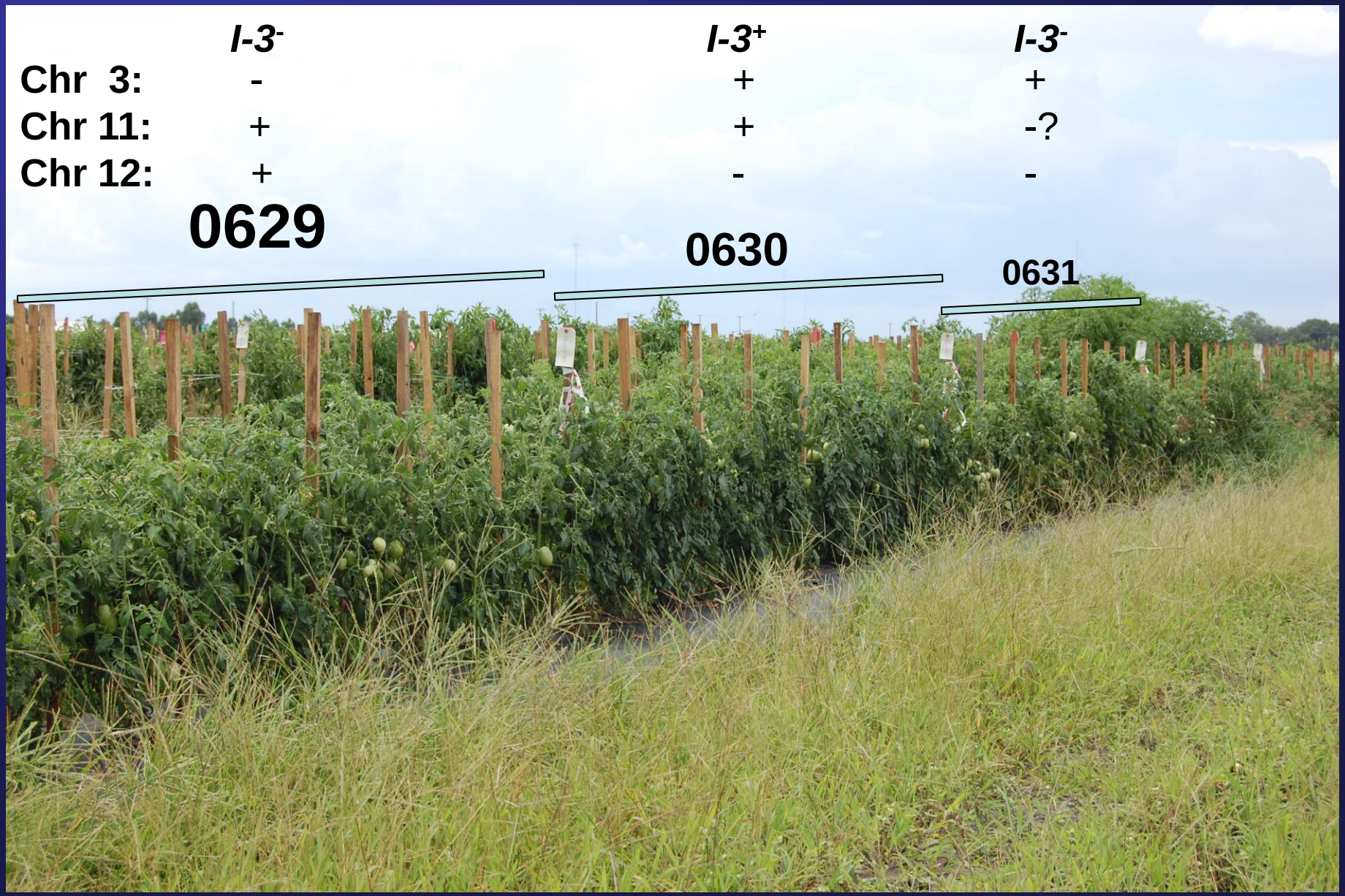

Fascinating presentation Dr. Scott

Fla. 7946: Fusarium wilt race 3 resistant, very susceptible to bacterial spot

Fla. 8517: Good bacterial spot tolerant line with PI 114490 and Hawaiian lines in it’s background

0630

Severity Rating = 2.5


I-3-
I-3+
I-3-
Chr 3:
-
+
+
Chr 11:
+
+
-?
Chr 12:
+
-
-
0629
0630
0631


Fla. 8208 x Fla. 8626
Brand X

Summary: Non-blighting

- Modified backcrossing proceeding phenotypically by selecting for earliness and yield
- Molecular markers linked to non-blighting would likely expedite our progress
- We will gladly accept funding for this project!

Fla. 8111B: Major Characteristics

- Large globe shaped fruit, strong vine, mid-season maturity
- Smooth, firm, crack resistant
- Graywall Resistant
- Good combiner for F_1 hybrids
- Very susceptible to bacterial spot

Is it Time for a Transgenic Tomato Variety?!

John. (Jay) W. Scott
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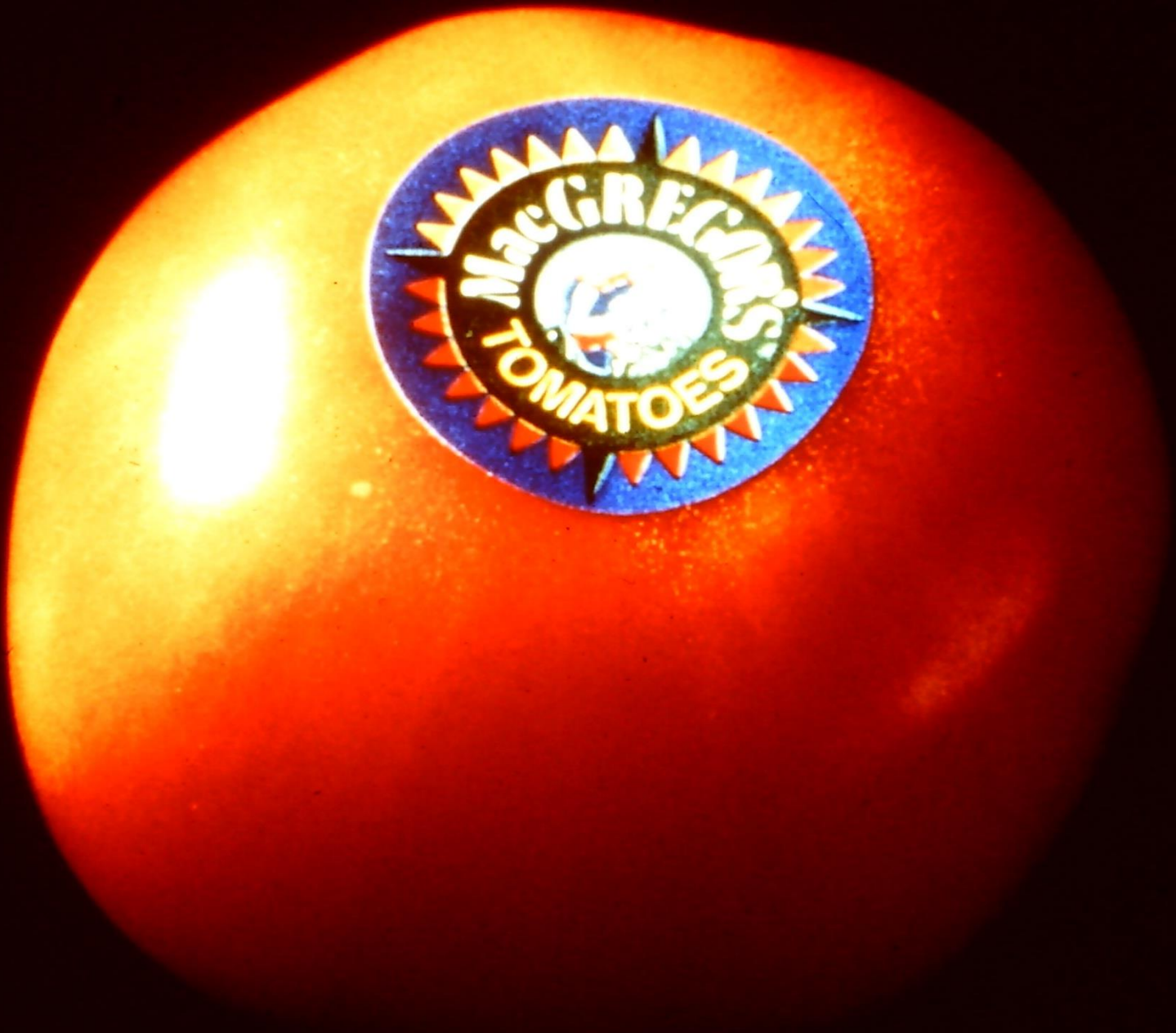

MacGREGOR'S
TOMATOES

Two Blades Foundation

- Mission to support the development and deployment of disease resistance in crops
- Driven by advances in molecular plant sciences and sequencing permitting access to a larger repertoire of disease resistance genes
- Goal to reduce crop losses due to disease, enhance food security
- Commercial and humanitarian applications

Effective genetic resistance to BLS Bs2 Project

- Project first undertaken by 2Blades in 1992
- At that time:
  - BLS was a widespread problem on tomato and pepper
  - Known resistances in pepper (BS1-3)
  - Xanthomonas effectors were characterized

Widespread distribution and fitness contribution of *Xanthomonas campestris* avirulence gene *avrBs2*

1990 Nature 346: 385-6

Brian Kearney & Brian J. Staskawicz

Department of Plant Pathology, University of California, Berkeley, California 94720, USA

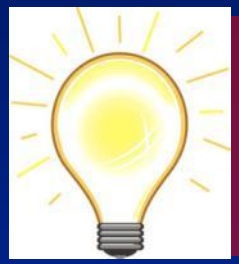
TABLE 1 Distribution of *avrBs2* activity and DNA homology within *Xanthomonas*

Strain	Hypersensitivity on ECW20R	*avrBs2* Homology
X. c. vesicatoria	yes	yes
X. c. alfalfae	yes	yes
X. c. phaseoli	yes	yes
X. c. malvacearum	yes	yes
X. c. campestris	yes	yes
X. c. vitians	yes	yes
X. c. vignicola	yes	yes
X. c. glycines	no	yes
X. c. holcicola	no	yes
X. c. oryzae	—	yes
X. c. citri	—	yes
X. fragariae	no	no

- **AvrBs2 widely distributed**
- **Function conserved**

2Blades

Crop Development Process



Discovery

proof of concept

Characterization

Line selection

IP filing

Field Trials

Regulatory Approvals

Seed increase, marketing, distribution

New Commercial product

UCB

2Blades

2Blades/UF

2Blades


I told them it was just a pepper gene in a tomato!

Total and extra-large marketable yield, fruit size and cull weights for tomato inbreds and hybrids with and without the pepper *Bs2* gene, Fall 2011, GCREC.

Entry[z]	Marketable yield (25 lb box/A)		Fruit Size	Culls	Bacterial spot disease severity[y]
	Total	Extra-large	(oz.)	(% by wt.)	
Fla. 8000 *Bs2* homo	2362 a[x]	906 bc	5.1 cd	27	5.4
Fla. 8314 *Bs2* homo	2237 ab	1232 a	5.6 a-c	21	4.0
Fla. 8000 *Bs2* hemi	1918 b	1060 ab	5.8 ab	26	4.3
Florida 47	1099 c	682 c	6.2 a	23	5.5
Fla. 8314	1093 c	588 c	5.5 bc	23	5.6
Fla. 8000	1028 c	253 d	4.8 d	28	5.1

[z] Genotypes with *Bs2* gene indicated by *Bs2*, hemi = 1 copy, homo = 2 copies.

[y] Rated on the Horsfall-Barrett Scale, 4 = 6-12% defoliation; 5 = 12-25% defoliation; 6 = 25-50% defoliation.

[X] Mean separation in columns by Duncan's multiple range test at $P \leq 0.05$.

Bacterial spot disease severity for tomato inbreds and hybrids with and without the Bs2 pepper gene, GCREC Spring 2012.

Genotype	Disease Severity [z]
VF 36	9.25 a[y]
Fla. 8111 B	8.75 a
Florida 47	7.38 b
Sebring	7.13 bc
Xv4 F_1	6.5 b-d
Fla. 8000	6.5 b-d
Florida 91	6.25 b-e
Fla. 8314	6.25 b-e
Xv4 line	6.13 c-e
Sanibel	5.67 de
104009-29 (susceptible)	5.25 e
104009-8 *Bs2*	2.75 f
VF36 Bs2 hemi	2.5 f
104009-13 *Bs2*	2.5 f
VF 36 Bs2 homo	2.5 f
104009-5 *Bs2*	2.45 f
104009-26 *Bs2*	2.25 f
Fla. 8111B *Bs2* homo	2.25 f
Xv4 *Bs2* F_1	2.25 f
Fla. 8314 *Bs2* homo	2.0 f
104009-12 *Bs2*	2.0 f
Fla. 8000 *Bs2* homo	2.0 f

[z] Horsfall- Barratt scale, higher number means more disease.

[y] Mean separation by Duncan's Multiple Range Test at $P \leq 0.05$.


Fla. 8314 *Bs2*
VF 36

Total and extra-large marketable yield, fruit size, and cull weights for tomato inbreds and hybrids with and without the pepper *Bs2* gene, Spring 2012, GCREC.

	Marketable Yield (25 lb box/A)		Fruit size	Culls
Entry[z]	Total	Extra-large	(oz)	(% by wt.)
Fla. 8000 *Bs2*	2122 a[y]	566 bc	5.1 f	28.4 e
Fla. 8314 *Bs2*	1725 ab	849 a	6.2 cd	31.8 de
Fla. 8000	1648 b	403 c-e	5.3 ef	42.0 cd
Xv4 *Bs2* F_1	1615 b	507 b-d	5.3 ef	43.0 cd
9-3-20 SUSC	1579 b	228 de	4.9 f	44.4 b-d
9-3-5 *Bs2*	1524 b	201 e	4.8 f	46.5 bc
Florida 91	1357 b-c	855 a	6.9 b	47.9 bc
Sanibel	1003 cd	467 c-e	6.2 cd	56.9 a-c
Fla. 8314	967 cd	395 c-e	5.8 de	56.3 a-c
Fla. 8111 *Bs2*	892 cd	750 ab	7.9 a	57.6 a-c
Fla. 8111	764 d	371 c-e	6.2 cd	67.9 a
Sebring	707 d	367 c-e	6.5 bc	64.7 a
Florida 47	665 d	272 de	5.9 de	68.0 a

[z] *Bs2* indicates genotype is homozygous for the *Bs2* gene.
[y] Mean separation in columns by Duncan's Multiple Range Test at $P \leq 0.05$.

MAS Trait Integration

Traits

Ty-1

Ty-2

Ty-3

Ty-4

Ty-5

(*Ty-6*)

Sw-5

Sw-7

Frl

Pto

Ph-2

Ph-3

Recurrent Parents

7770	8208	8611
7776	8249	8620
7781	8283	8623
7804	8293	8626
7907B	8296	8640
7946	8297	8646
7949B	8436B	8650
7987	8490B	8653B
8000	8495	8735
8021	8499	8820
8044	8589	8834
8059	8590	8835
8083	8591	8872
8111B	8592	8877
8124C	8599	8878
	8608	

Yield of tomato genotypes with the *Bs2* pepper gene compared to genotypes without *Bs2*, Balm, Florida, Fall 2012.

	Marketable yield (25 lb. box/acre)		Fruit size	Culls
Entry	Total	Extra-large	(g)	(% by wt.)
8455 *Bs2, Ty1*	2780a	2207a	204a-c	11e
8111B x 7781 *Bs2, Ty1 Fr1*	2737a	1860ab	208a-c	14de
8314 *Bs2*	2508ab	1933ab	195b-e	15de
8735 x 8000 *Bs2*	2505ab	1836ab	184c-e	15de
8000 Bs2	2476ab	1654b	177d-f	24b-e
8726 *Bs2, Ty1,I3*	2424ab	2025ab	214ab	17c-e
8476 x 8111B *Bs2*	1867bc	1431c	199a-e	13de
8314	1434cd	920de	175ef	34ab
8000	1300cd	398f	142f	28b-d
8455	1202cd	953d	202a-c	36a
Sanibel	1129d	904de	203a-c	39a
8726	1089d	926de	220a	31a-d
Florida 91	1056d	904de	223a	34ab
Florida 47	934d	810ef	200a-d	42a

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Home > Products > Professional Growers > Products > Summer Squash > Conqueror III Print This Page

Summer Squash Varieties: Conqueror III GO

Conqueror III

Conqueror III is a green-stem straightneck with transgenic resistance to CMV, WMV and ZYMV and intermediate resistance to papaya ring spot. The fruit is a uniform, creamy yellow color and the plant is vigorous and semi-open.

Fruit Color	Glossy lemon yellow, Green peduncle
Fruit shape	Straight, Slightly crooked neck, Tapered
Fruit size	6-7 in.; 16-18 cm
Plant type	Vigorous medium
Relative Days to Maturity	41

Independence II

Judgement III

Justice III

Liberator III

Patriot II

Prelude II

XPT 1832 III

Chemistry Cost

Per season:

Compound	Ave price $/ lb AI	Appln Rate	# Applns (with BLS)	Total cost FL	Total cost FL/ EC/ Mex
Mancozeb (Dithane DF)	$1.65	1.5-2	44.8	$3,592,512	$14,414.400
Copper hydroxide (Kocide 101)	$3.25	1.5	44.8	$7,076,160	$28,392,000

2009 prices from one representative provider

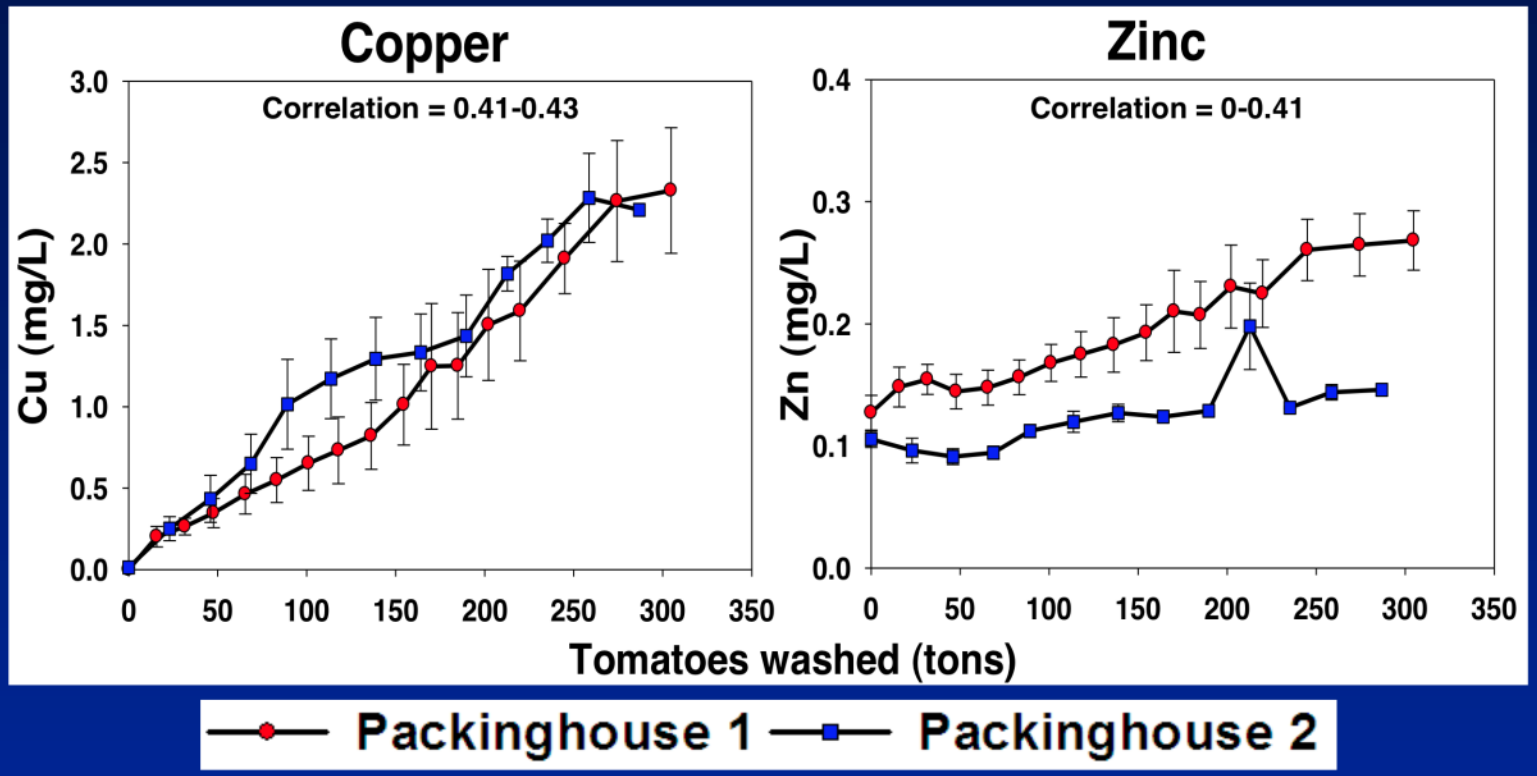
Applications rates and number of applications from discussions with Glades Crop Care (2009)

FL acres average 32,400; Acres for FL, East Coast and Mexico are 130,000.

Costs do not include labor

2Blades

EVOLUTION OF COPPER AND ZINC IN WASTEWATER



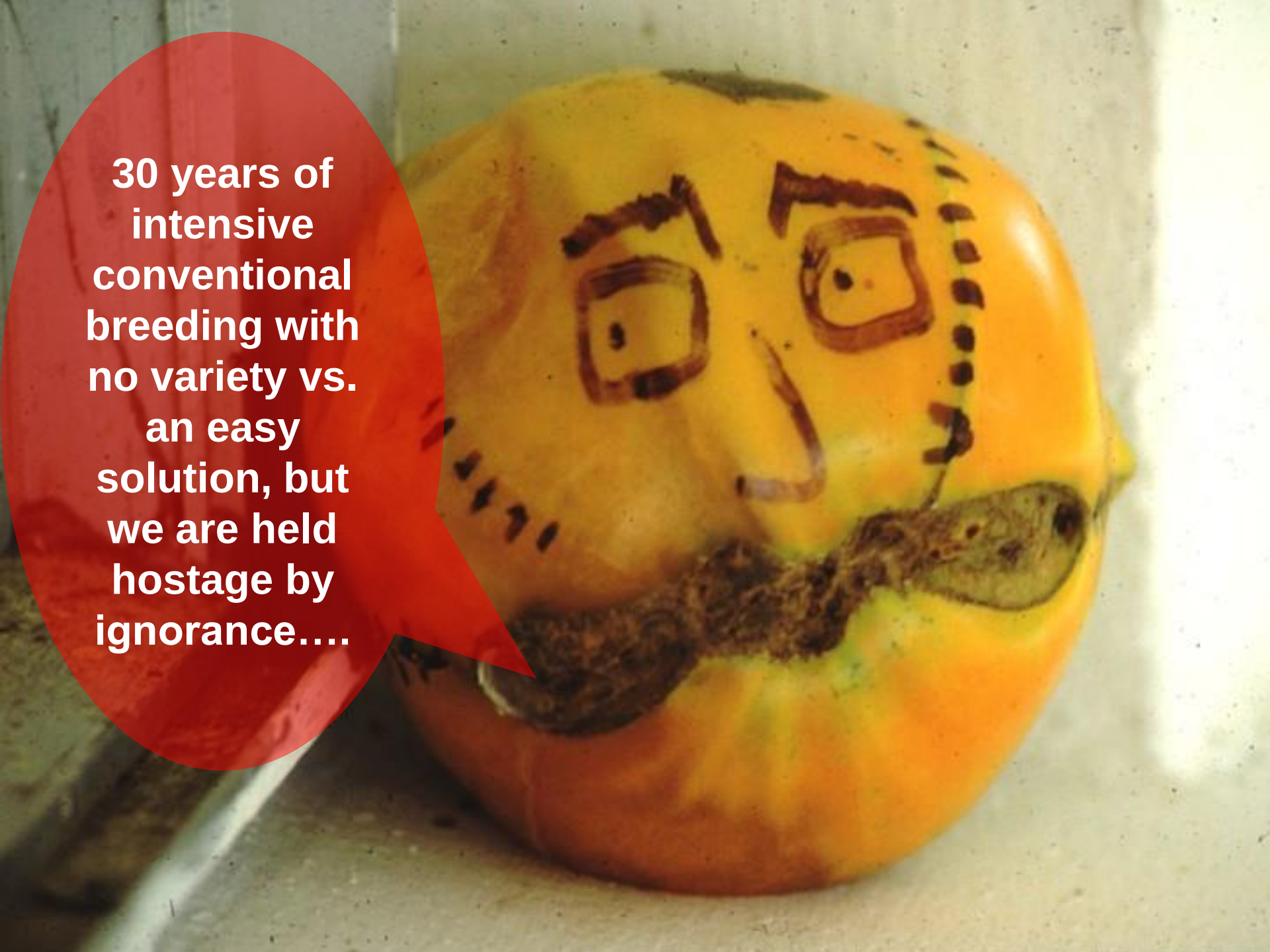
- Copper increased linearly with the washing of tomatoes.
- Zinc increased more in PKG 1 than PKG 2.

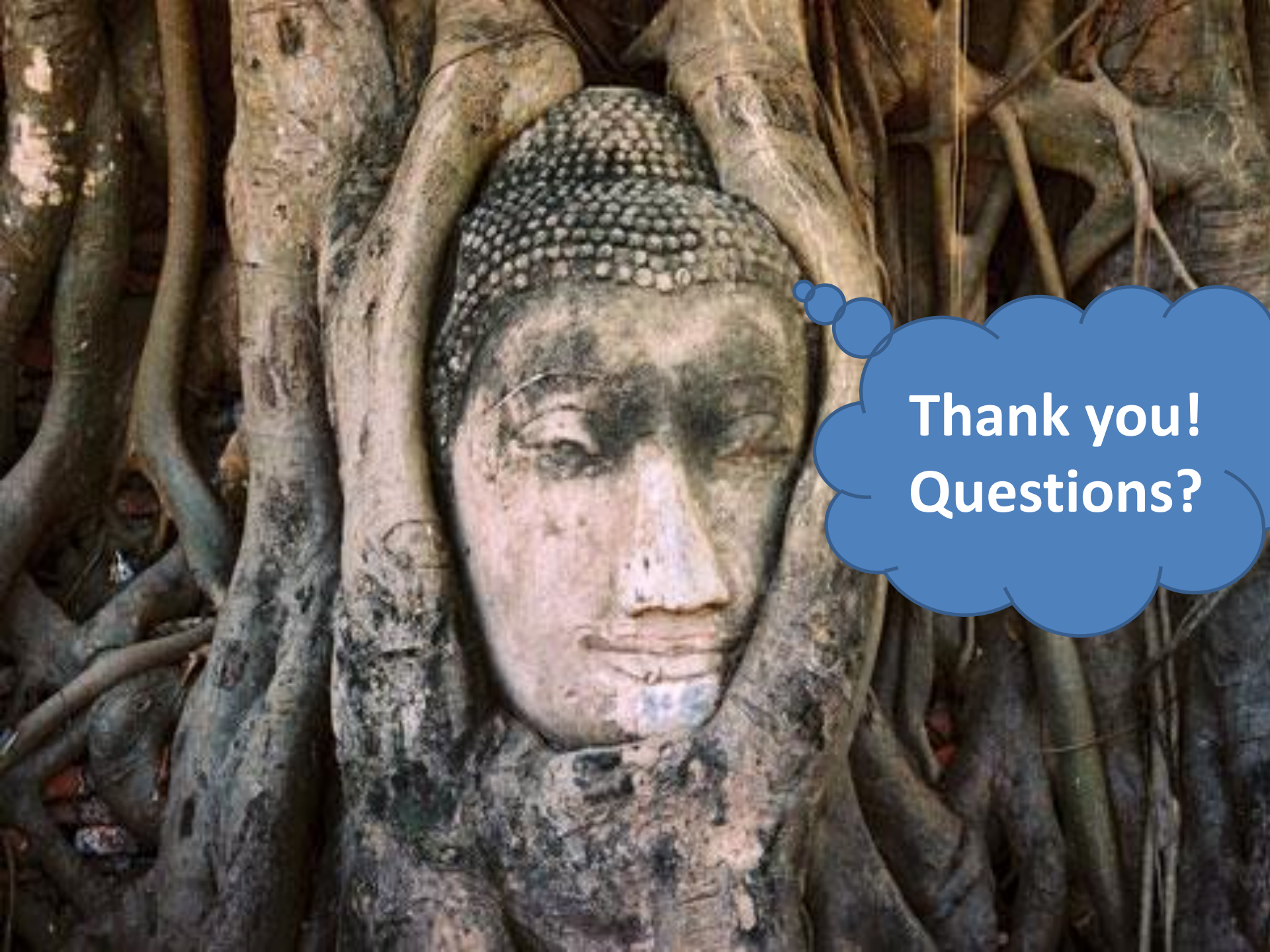
Toor, Chahal and Santos (2010) Tomato Institute Meeting

Transgenic BLS Resistant Fresh Market Tomato: From proof of principle to product

- Improved gene cassette
  - Only pepper and tomato DNA
  - No antibiotic selection gene
- Florida adapted varieties-reliable yields
- Green technology-less pesticides needed
- We are testing hybrids that have *Bs2* and resistance to TYLCV, fusarium crown rot, fusarium wilt race 3, TSWV
- In the future we hope to improve resistance durability by adding *Xv4, EFR* genes, and QTLs.


Worth1000.com


30 years of intensive conventional breeding with no variety vs. an easy solution, but we are held hostage by ignorance….


Thank you!
Questions?