Extended Field Storage (EFS) in Processing Tomatoes: Does it Fit in CA Production?

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Making a Difference for California

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Tomato Transplant Growers

Tomato Seed Companies & Distributors

EFS Variety Trials (2004-2009)

Sometimes we have to wait in line.
Maybe EFS varieties could help us
wait patiently in the field **?**

INTRODUCTION
EFS Variety Evaluations

- Certain processing tomato varieties have been bred for Extended Field Storage (EFS).
- Some EFS lines are in UC statewide variety trials.
- The UC protocol does not address the potential for extended field storage.

INTRODUCTION

EFS Variety Evaluations

- Yields DECREASE when HOT TEMP occur for sustained periods and disrupt fruit set.
- Previous work by others looked at planting EFS lines EARLY and harvesting them LATE.
- Perhaps some EFS varieties can set fruit well in the heat and/or store well in the field?

Why EFS Variety Trials ?

1. What can we expect to happen to tomato yields & quality if varieties are held in the field?
2. Are some EFS lines better than others at field storage?
3. Can EFS lines be a Harvest Management Strategy?
4. Can EFS lines be an answer to the heat set problem?

OBJECTIVES
EFS Variety Evaluations

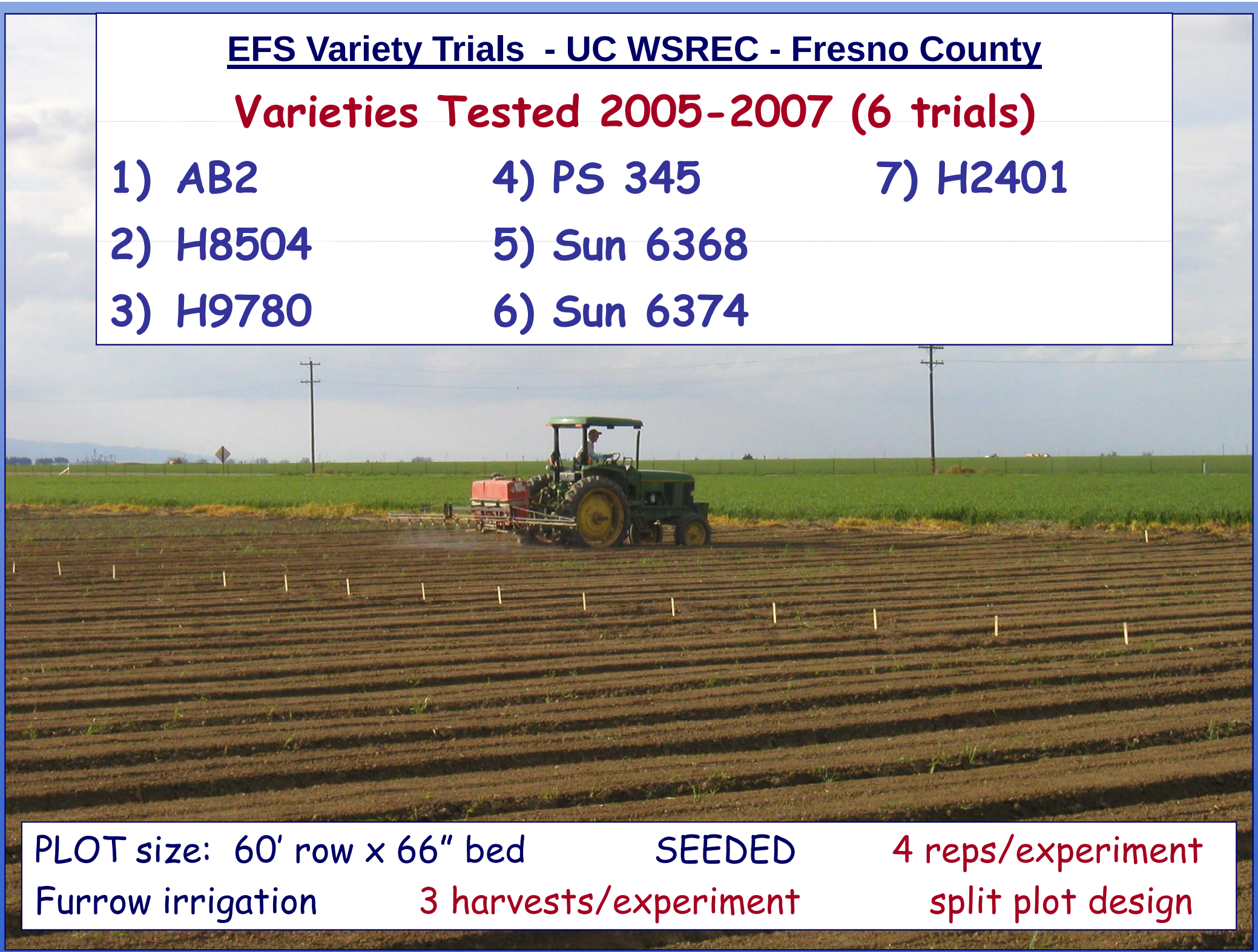
1) Evaluate EFS lines over harvest dates that span several weeks.

2) Evaluate yield and quality differences within and between the EFS varieties over time of harvest.

EFS Variety Trials - UC WSREC - Fresno County

Varieties Tested 2005-2007 (6 trials)

1) AB2
2) H8504
3) H9780
4) PS 345
5) Sun 6368
6) Sun 6374
7) H2401



PLOT size: 60' row x 66" bed — SEEDED — 4 reps/experiment

Furrow irrigation — 3 harvests/experiment — split plot design

2005 EFS Variety Trials - UC WSREC - Fresno County

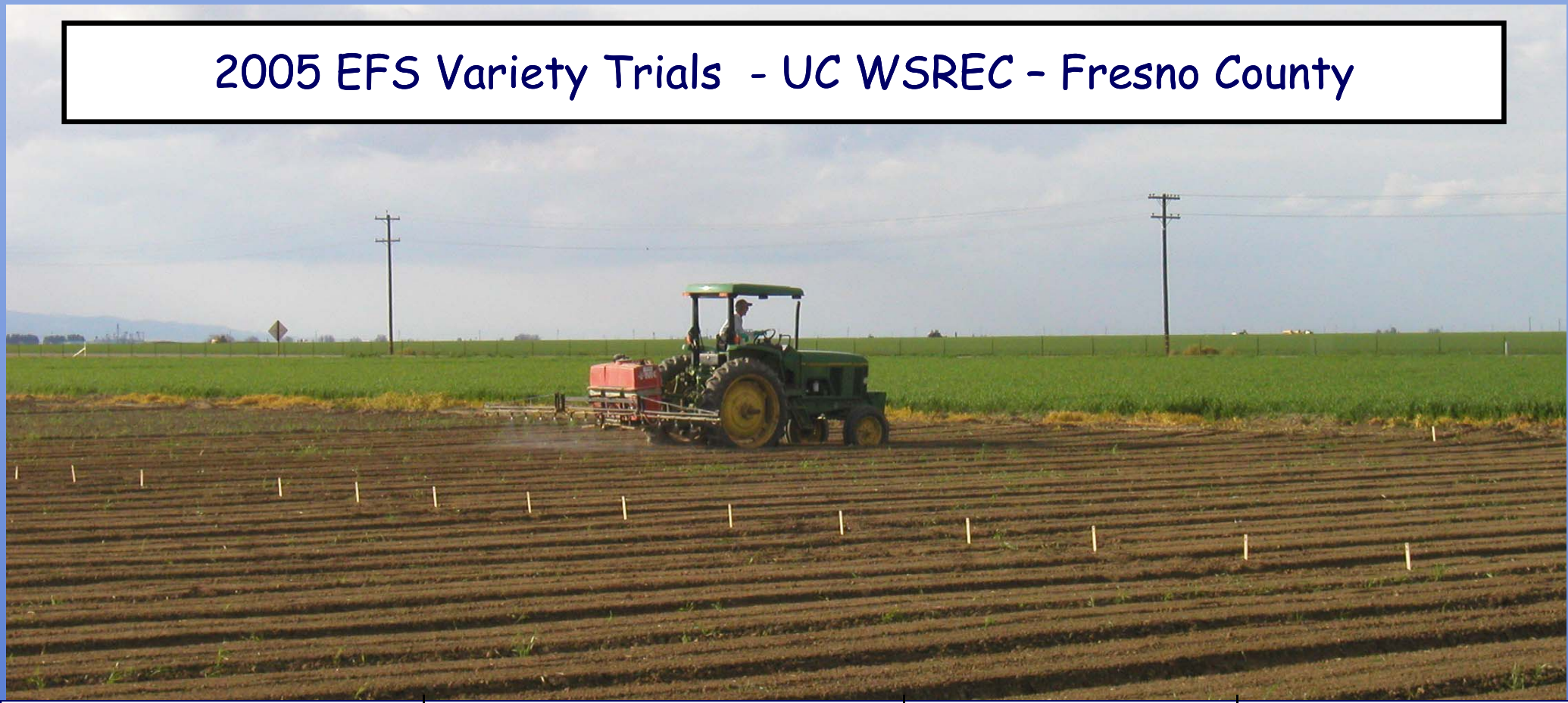
Varieties Tested

1) Halley 3155
2) H 8504
3) H 9780
4) H 9997
5) Hypeel 849
6) PS 345
7) Sun 6368
8) Sun 6374
9) U 567
10) U 37
11) U 886
12) AB 2

PLOT size: 60' row x 66" bed — 4 reps/experiment

Furrow irrigation — 3 harvests/experiment — split plot design

2005 EFS Variety Trials - UC WSREC – Fresno County

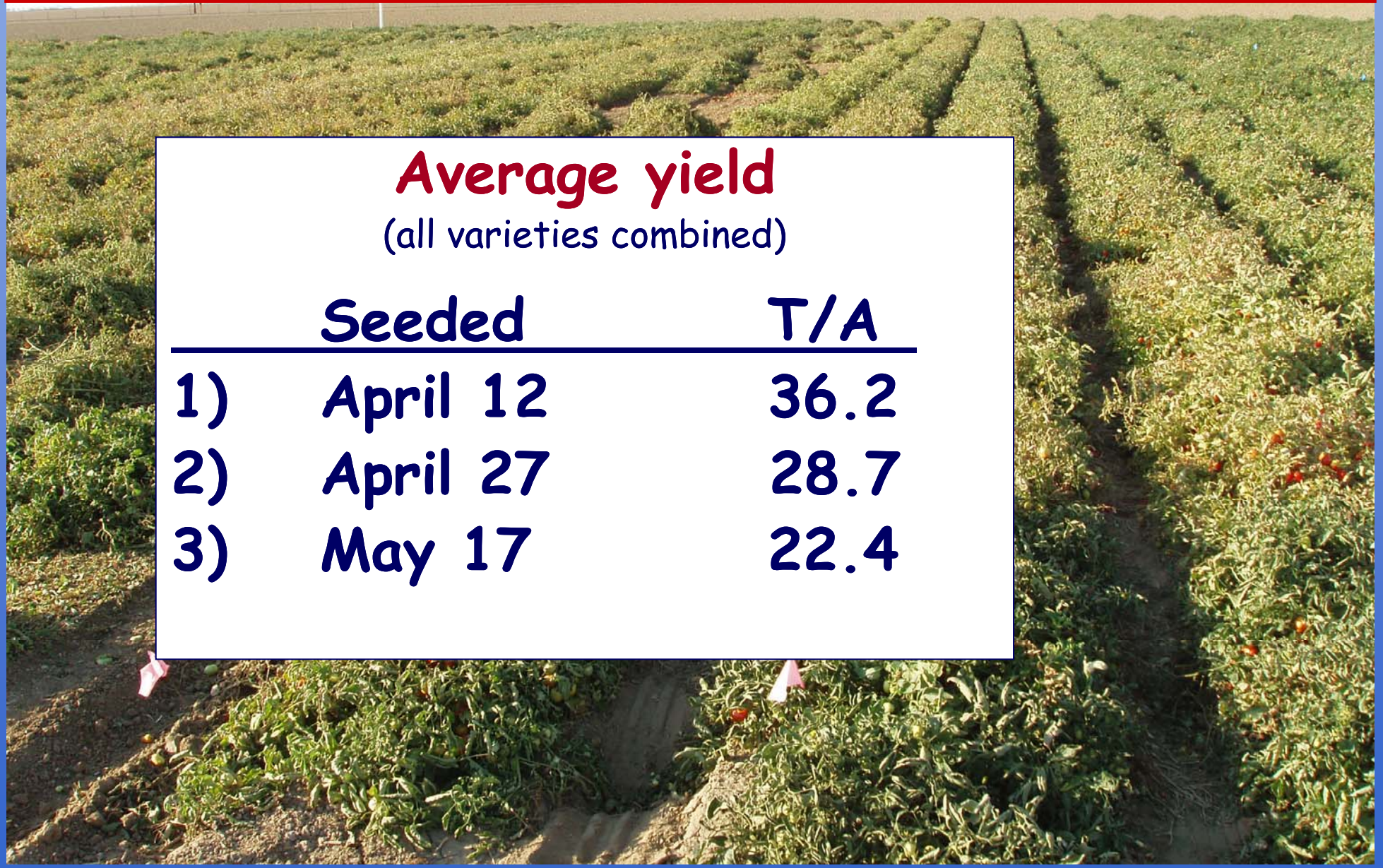


Expt.	Seeded	Harvest 1	H2	H3
#1	April 12	Aug 29 (139 DAS)	Sept 12	Sept 19
#2	April 27	Sept 12 (138 DAS)	Sept 26	Oct 3
#3	May 17	Sept 26 (132 DAS)	Oct 3*	----

* only 7 days after H #1


• 384 plots total
• Machine harvested
• Samples collected for PTAB
• Samples collected for UCD Food Science Lab

Observed RESULTS



Average yield

(all varieties combined)

	Seeded	T/A
1)	April 12	36.2
2)	April 27	28.7
3)	May 17	22.4

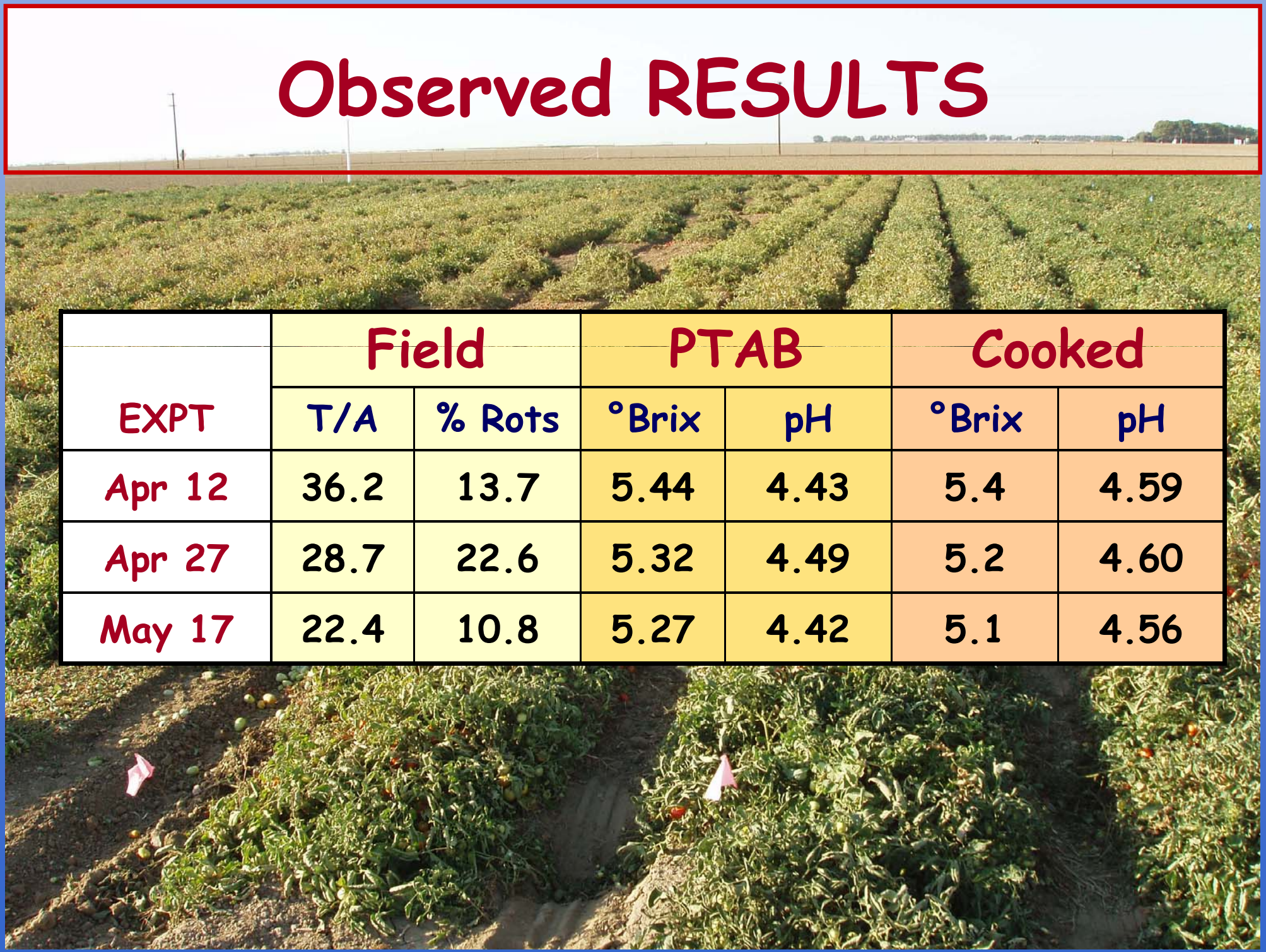
RESULTS

	Tons/Acre				% Green fruit			
EXPT	H1	H2	H3	LSD	H1	H2	H3	LSD
Apr 12	38.0	36.8	33.7	2.1	1.9	1.7	1.6	NS
Apr 27	33.2	28.2	24.9	1.6	3.7	4.8	6.5	1.2
May 17	21.3	23.5	--	2.0	23.5	20.5	--	2.6

RESULTS

EXPT	Harvest Dates					AVG
	Aug 29	Sept 12	Sept 19	Sept 26	Oct 3	
Apr 12	38.0	36.8	33.7			36.2 T/A
Apr 27		33.2		28.2	24.9	28.7 T/A
May 17				21.3	23.5	22.4 T/A

Observed RESULTS



EXPT	Field		PTAB		Cooked	
	T/A	% Rots	°Brix	pH	°Brix	pH
Apr 12	36.2	13.7	5.44	4.43	5.4	4.59
Apr 27	28.7	22.6	5.32	4.49	5.2	4.60
May 17	22.4	10.8	5.27	4.42	5.1	4.56

Table 1: Grower's main interest

EXPT. 1 Seeded April 12, 2005

Harvest 1: AUG 29 (139 DAS)
Harvest 2: SEPT 12
Harvest 3: SEPT 19

Variety & code	Yield Tons/A				% Rots				°BRIX			
	H1	H2	H3	AVG	H1	H2	H3	AVG	H1	H2	H3	AVG
2. H 8504	43.7	44.6	49.5	**45.9**	3.6	2.9	6.1	**4.2**	5.45	5.30	5.18	**5.31**
3. H 9780	46.0	43.0	38.4	**42.5**	5.9	5.8	19.3	**10.3**	5.68	5.48	5.45	**5.53**
6. PS 345	40.6	38.4	43.9	**41.0**	4.2	7.0	17.5	**9.6**	5.30	5.23	5.18	**5.23**
4. H 9997	45.0	40.1	35.5	**40.2**	7.2	7.7	25.2	**13.4**	4.90	4.88	4.70	**4.83**
9. U 37	37.3	43.3	36.7	**39.1**	8.0	7.3	11.7	**9.0**	5.33	4.98	5.15	**5.15**
5. Hypeel 849	36.3	34.5	38.6	**36.5**	4.7	16.1	14.1	**11.6**	5.78	5.00	5.10	**5.29**
7. Sun 6368	33.2	34.2	33.2	**33.5**	7.0	8.7	17.8	**11.2**	6.28	5.98	5.45	**5.90**
12. AB 2	35.1	35.0	26.7	**32.3**	10.3	13.5	33.2	**19.0**	5.98	5.78	5.65	**5.80**
8. Sun 6374	33.6	34.9	26.1	**31.5**	8.4	13.1	28.4	**16.6**	6.20	6.20	6.13	**6.18**
11. U 886	33.6	34.6	25.1	**31.1**	9.3	20.3	32.0	**20.5**	5.38	5.35	5.40	**5.38**
1. Halley 3155	32.1	29.8	29.6	**30.5**	8.8	14.4	20.6	**14.6**	6.15	5.65	5.13	**5.64**
10. U 567	39.2	29.7	20.9	**29.9**	10.0	32.7	31.4	**24.7**	5.10	5.00	4.95	**5.02**
average	**38.0**	**36.8**	**33.7**	**36.2**	**7.3**	**12.5**	**21.4**	**13.7**	**5.63**	**5.40**	**5.29**	**5.44**
LSD 5% (Var)				4.2				4.9				0.22
LSD (Har)	----------	2.08	----------		----------	2.43	----------		---------	0.108	----------	
LSD (Var X Har)	7.2				8.4				0.37			
CV %				14.3				43.8				4.90

Table 2: Grower's main interest

EXPT. 2 Seeded April 27, 2005

Harvest 1: SEPT 12 (138 DAS)
Harvest 2: SEPT 26
Harvest 3: OCT 3

Variety & code	Yield Tons/A				% Rots				°BRIX			
	H1	H2	H3	AVG	H1	H2	H3	AVG	H1	H2	H3	AVG
2. H 8504	33.2	34.4	36.3	**34.7**	4.7	7.8	21.9	**11.5**	5.03	5.25	5.20	**5.16**
4. H 9997	44.0	30.3	28.0	**34.1**	7.6	30.2	49.3	**29.0**	4.83	4.85	4.95	**4.88**
6. PS 345	34.6	36.7	26.7	**32.7**	7.9	12.5	38.3	**19.5**	5.18	5.13	5.25	**5.18**
7. Sun 6368	36.6	32.2	28.8	**32.5**	6.0	17.5	31.3	**18.3**	5.73	5.75	5.28	**5.58**
9. U 37	35.0	29.4	29.9	**31.4**	4.3	10.3	19.1	**11.2**	5.10	5.03	4.98	**5.03**
3. H 9780	35.8	31.5	26.2	**31.2**	5.6	12.6	25.4	**14.5**	5.58	5.38	5.45	**5.47**
8. Sun 6374	32.7	30.4	27.4	**30.1**	11.0	22.5	31.7	**21.7**	6.05	5.93	5.45	**5.81**
5. Hypeel 849	32.1	26.4	23.8	**27.4**	5.3	19.3	38.6	**21.0**	5.20	5.33	5.15	**5.23**
11. U 886	30.2	25.3	19.6	**25.0**	15.7	24.2	38.1	**26.0**	5.28	5.30	5.43	**5.33**
1. Halley 3155	28.0	24.7	19.8	**24.2**	7.6	26.4	51.8	**28.6**	5.50	5.20	5.23	**5.31**
12. AB 2	27.4	16.4	19.8	**21.2**	14.1	34.5	45.7	**31.4**	5.65	5.60	5.55	**5.60**
10. U 567	28.5	20.9	12.3	**20.6**	23.5	40.5	50.2	**38.1**	5.00	5.33	5.45	**5.26**
average	**33.2**	**28.2**	**24.9**	**28.7**	**9.4**	**21.5**	**36.8**	**22.6**	**5.34**	**5.34**	**5.28**	**5.32**
LSD 5% (Var)				3.2				6.8				0.15
LSD (Har)	----------	1.60	----------		----------	3.41	----------		----------	NS	----------	
LSD (Var X Har)	5.6				NS				0.26			
CV %				13.8				37.3				3.50

Table 3: Grower's main interest

EXPT. 3 Seeded May 17, 2005

Harvest 1: SEPT 26 (132 DAS)

Harvest 2: OCT 3 (only 7 days later)

Variety & code	Yield Tons/A			% Rots			°BRIX		
	H1	H2	AVG	H1	H2	AVG	H1	H2	AVG
4. H 9997	28.5	24.9	**26.7**	7.5	16.4	**11.9**	5.03	4.98	**5.00**
7. Sun 6368	24.0	28.6	**26.3**	11.6	11.6	**11.6**	5.63	5.33	**5.48**
11. U 886	25.8	25.2	**25.5**	8.2	15.7	**11.9**	5.33	5.40	**5.36**
12. AB 2	23.1	26.4	**24.8**	10.5	20.1	**15.3**	5.53	5.48	**5.50**
9. U 37	19.0	27.1	**23.1**	10.0	13.2	**11.6**	5.25	4.85	**5.05**
2. H 8504	23.2	20.2	**21.7**	6.9	10.0	**8.4**	5.28	5.05	**5.16**
6. PS 345	19.5	22.4	**20.9**	5.2	8.0	**6.6**	5.10	5.05	**5.08**
10. U 567	16.7	21.1	**20.4**	10.7	14.0	**12.3**	5.20	4.98	**5.09**
3. H 9780	18.1	22.2	**20.2**	5.1	9.4	**7.3**	5.20	5.08	**5.14**
5. Hypeel 849	16.9	23.4	**20.1**	4.2	8.2	**6.2**	5.28	5.18	**5.23**
8. Sun 6374	21.0	18.5	**19.7**	11.1	13.7	**12.4**	5.83	5.75	**5.79**
1. Halley 3155	16.8	21.6	**19.2**	10.4	18.3	**14.4**	5.50	5.28	**5.39**
average	**21.3**	**23.5**	**22.4**	**8.4**	**13.2**	**10.8**	**5.34**	**5.20**	**5.27**
LSD 5% (Var)			4.9			5.6			0.19
LSD (Har)	----- 2.01 ----			----- 2.28 -----			----- 0.079 -----		
LSD (Var X Har)	NS			NS			NS		
CV %			22.1			51.8			3.68

Processor's interest is somewhat different from Grower's

Fruit Quality Differences

EFS Variety Trials

EXPT. 1 Seeded April 12, 2005

Harvest 1: AUG 29
Harvest 2: SEPT 12
Harvest 3: SEPT 19

PTAB & Cooked °BRIX

Variety & code	PTAB °BRIX				Cooked °BRIX			
	H1	H2	H3	AVG	H1	H2	H3	AVG
8. Sun 6374	6.2	6.2	6.1	**6.2**	6.3	6.1	6.1	**6.2**
7. Sun 6368	6.3	6.0	5.5	**5.9**	6.2	5.7	5.6	**5.8**
12. AB 2	6.0	5.8	5.7	**5.8**	6.1	5.5	5.6	**5.7**
1. Halley 3155	6.2	5.7	5.1	**5.6**	6.0	5.4	5.3	**5.6**
11. U 886	5.4	5.4	5.4	**5.4**	5.5	5.3	5.4	**5.4**
3. H 9780	5.7	5.5	5.5	**5.5**	5.7	5.2	5.2	**5.4**
5. Hypeel 849	5.8	5.0	5.1	**5.3**	5.6	5.0	5.2	**5.3**
2. H 8504	5.5	5.3	5.2	**5.3**	5.6	5.3	4.9	**5.3**
6. PS 345	5.3	5.2	5.2	**5.2**	5.4	5.2	5.1	**5.2**
9. U 37	5.3	5.0	5.2	**5.2**	5.4	5.0	5.0	**5.1**
10. U 567	5.1	5.0	5.0	**5.0**	5.2	5.0	4.7	**5.0**
4. H 9997	4.9	4.9	4.7	**4.8**	5.1	4.8	4.6	**4.8**
average	**5.6**	**5.4**	**5.3**	**5.4**	**5.7**	**5.3**	**5.2**	**5.4**
LSD 5% (Var)				0.2				0.2
LSD (Har)	---------	0.108	----------		----------	0.176	----------	
LSD (Var X Har)	0.4				NS			
CV %				4.9				3.8

EXPT. 1 Seeded April 12, 2005

Harvest 1: AUG 29
Harvest 2: SEPT 12
Harvest 3: SEPT 19

PTAB & Cooked pH

Variety & code	PTAB pH				Cooked pH			
	H1	H2	H3	AVG	H1	H2	H3	AVG
4. H 9997	4.43	4.61	4.61	**4.55**	4.56	4.79	4.93	**4.76**
10. U 567	4.45	4.54	4.59	**4.53**	4.64	4.67	4.84	**4.72**
6. PS 345	4.34	4.49	4.51	**4.44**	4.73	4.54	4.68	**4.65**
5. Hypeel 849	4.34	4.51	4.47	**4.44**	4.65	4.55	4.70	**4.64**
11. U 886	4.42	4.56	4.52	**4.50**	4.38	4.61	4.87	**4.62**
1. Halley 3155	4.32	4.42	4.39	**4.38**	4.68	4.48	4.66	**4.61**
9. U 37	4.34	4.49	4.35	**4.39**	4.51	4.55	4.70	**4.59**
7. Sun 6368	4.34	4.41	4.50	**4.42**	4.57	4.49	4.67	**4.58**
8. Sun 6374	4.31	4.45	4.57	**4.44**	4.45	4.53	4.70	**4.56**
3. H 9780	4.29	4.39	4.50	**4.40**	4.34	4.50	4.76	**4.53**
12. AB 2	4.31	4.41	4.39	**4.37**	4.21	4.43	4.58	**4.41**
2. H 8504	4.28	4.35	4.42	**4.35**	4.24	4.39	4.53	**4.39**
average	**4.35**	**4.47**	**4.49**	**4.43**	**4.50**	**4.54**	**4.72**	**4.59**
LSD 5% (Var)				0.06				0.16
LSD (Har)	--------	0.031	----------		----------	0.080	----------	
LSD (Var X Har)	NS				NS			
CV %				1.69				3.7

Experiments repeated in 2006 & 2007

Varietal differences definitely exist

Conclusions for 2005 - 2007

- Earlier plantings brought higher yields
- T/A decreased & % rots increased
- ° Brix was relatively stable
- Color was acceptable
- pH may be the limiting factor
- Varietal selection (as always) is key

Can EFS be a Harvest Management Strategy?

Is EFS an answer to the "heat set" problem?

Will Processors tolerate higher pH?

Then in 2009 ...

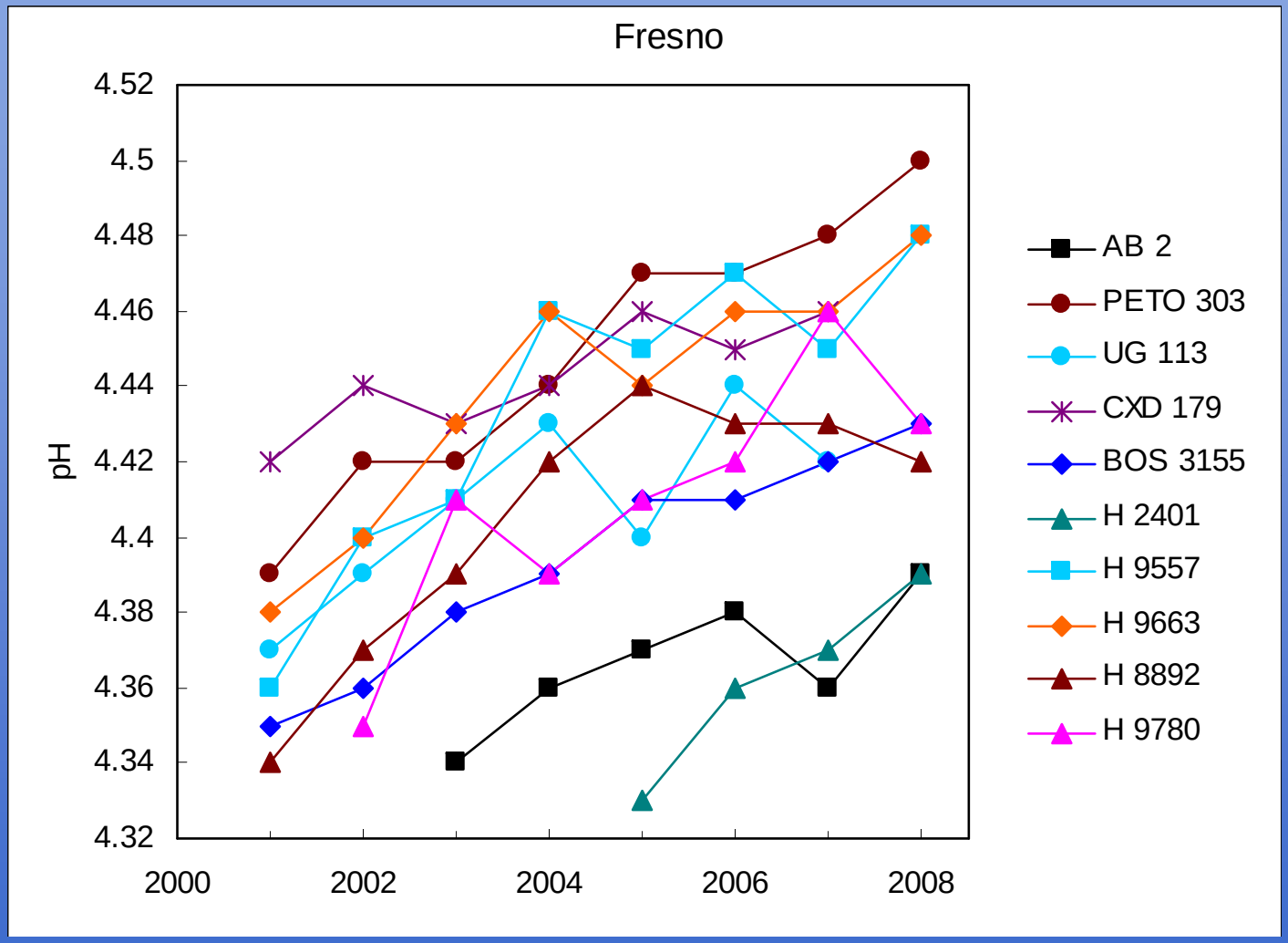
We investigated ...

pH Increases –
Are they real?

What factors could be affecting pH and acidity in tomatoes

Variety? Location grown and conditions? Fruit Maturity?

PTAB pH data for Fresno County



Trend of increasing pH from 2001 - 2008 is valid.

Conclusions from PTAB data

1. **pH increases occur for individual varieties grown in a single county. Statewide pH increase is:**
   - **Not due to introduction of new varieties**
   - **Not due to geographic shift in production**
2. **pH increase occurred in most varieties and in all 4 counties examined.**
3. **pH increase is possibly related to fruit maturity.**

Effects of fruit maturity (2009 Field Trials)

- **Grow 4 varieties: AB2, N6368*, H2401*, H9557 at UC Davis and UC West Side REC (Fresno).**
  Prepare and analyze microwave hot-break juice.

- **UC Davis - Fruit tagged at the turning color stage to identify a sub-set of fruit of uniform maturity.**
  Tagged fruit harvested weekly continuing for 5 weeks.

- **UC WSREC Fresno - Entire row section harvested at commercial maturity then weekly for 3 additional weeks.** ***Yield of red fruit determined.***

***Extended Field Storage (EFS) varieties**

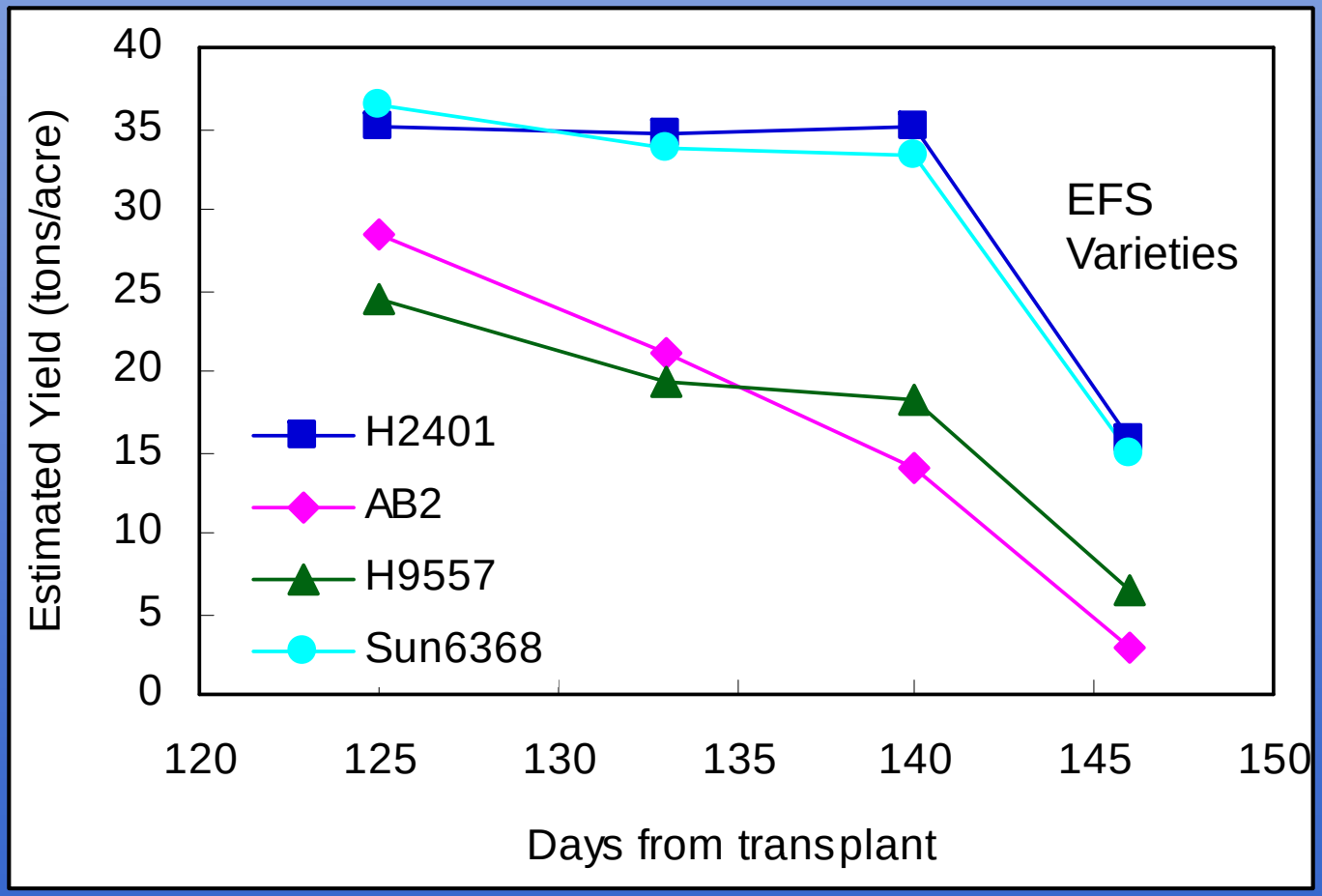
Biochemical analysis (UCD Food Science Lab)

- Microwave hot-break juice analyzed for **Brix, pH, Titratable Acidity, and Lycopene** by T4 students.

- Analysis of individual acids: **citric, malic, & glutamic** and sugars: **glucose and fructose.**

RESULTS: Fresno Trial - Yield of red fruit

Yield decreases if fruit is left in field for extended season.



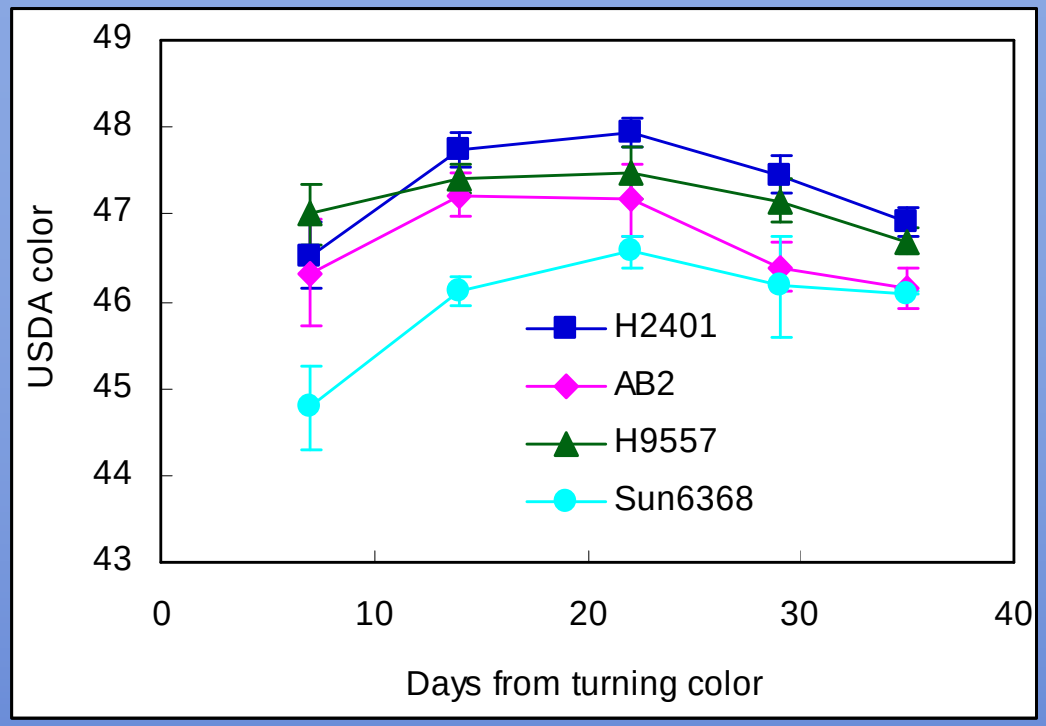
RESULTS:

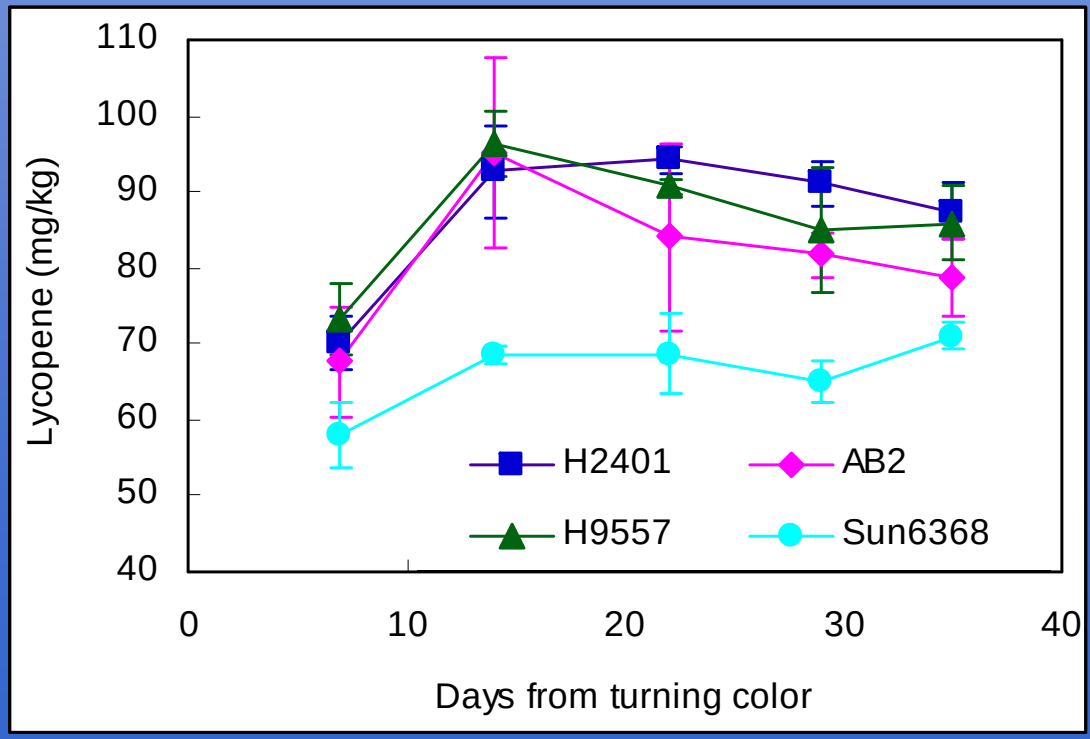
UC Davis Trial

Fruit maturity determined by color and lycopene

Sampling trial was started prior to peak maturity.

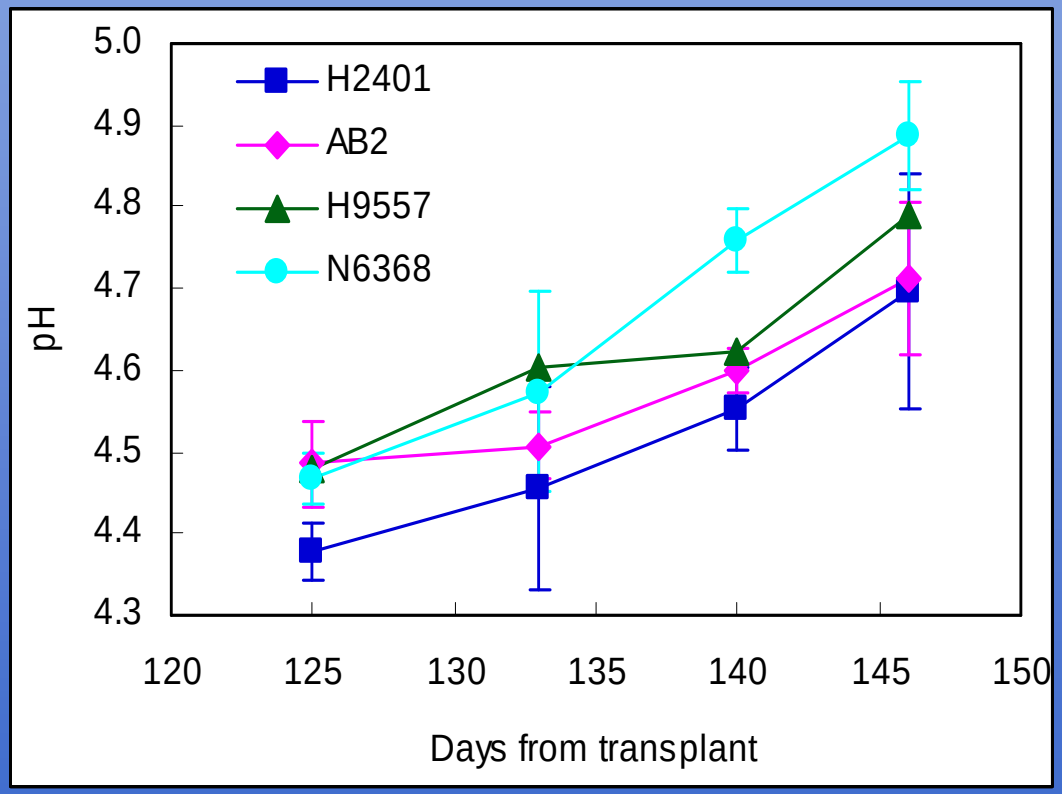
Both color and lycopene methods indicate color increases, then is fairly stable.



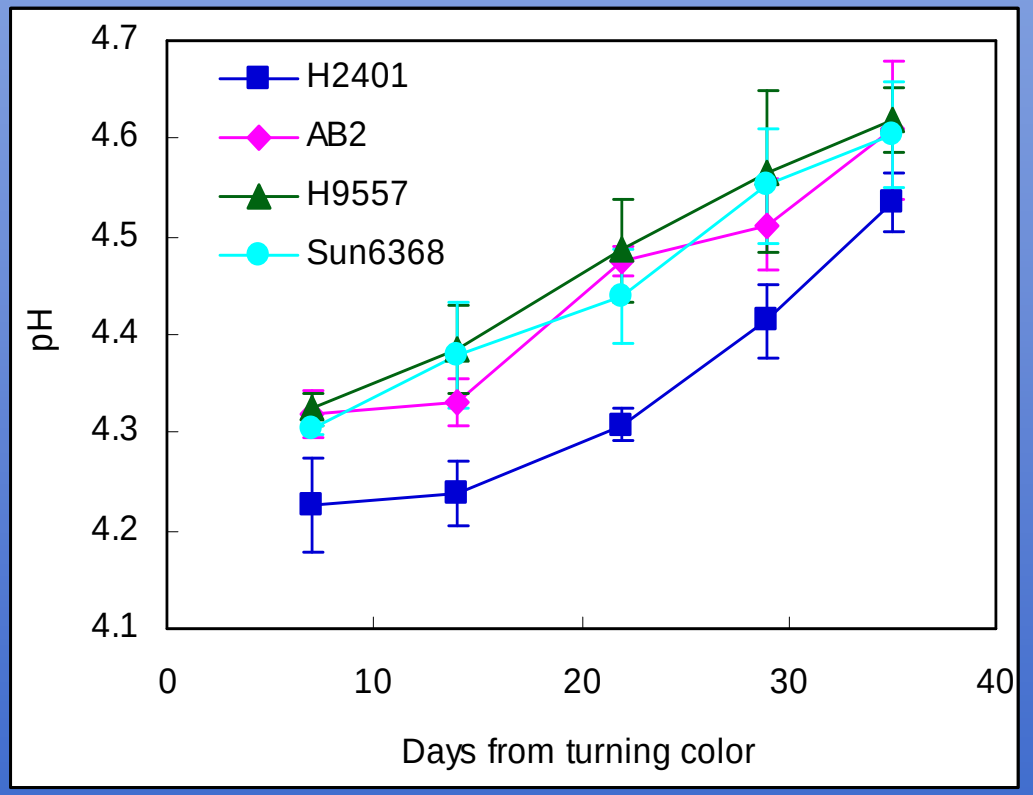


RESULTS: pH increased with maturity

Fresno



Davis



Both trials determined increases in pH with maturity.

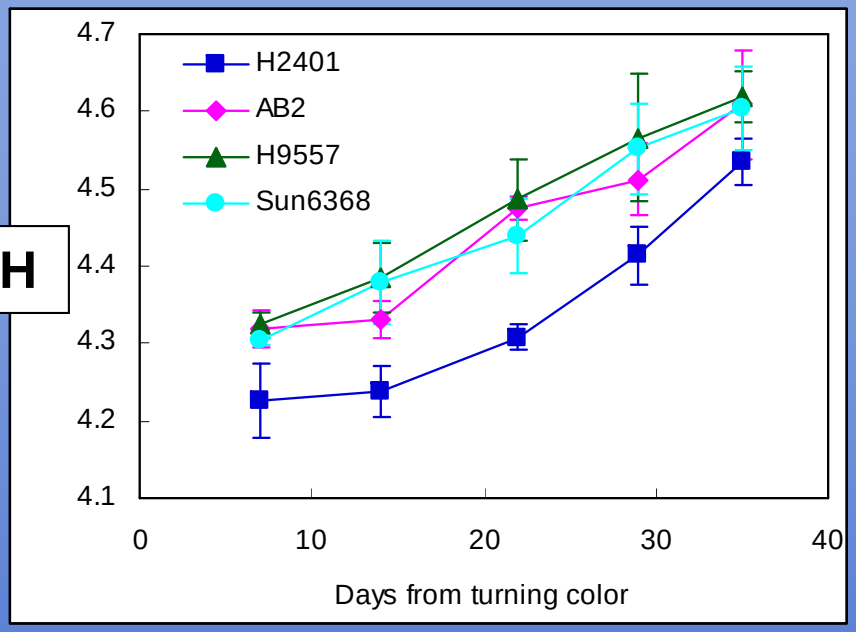
How does the maturity effect on pH compare with the yearly increases?

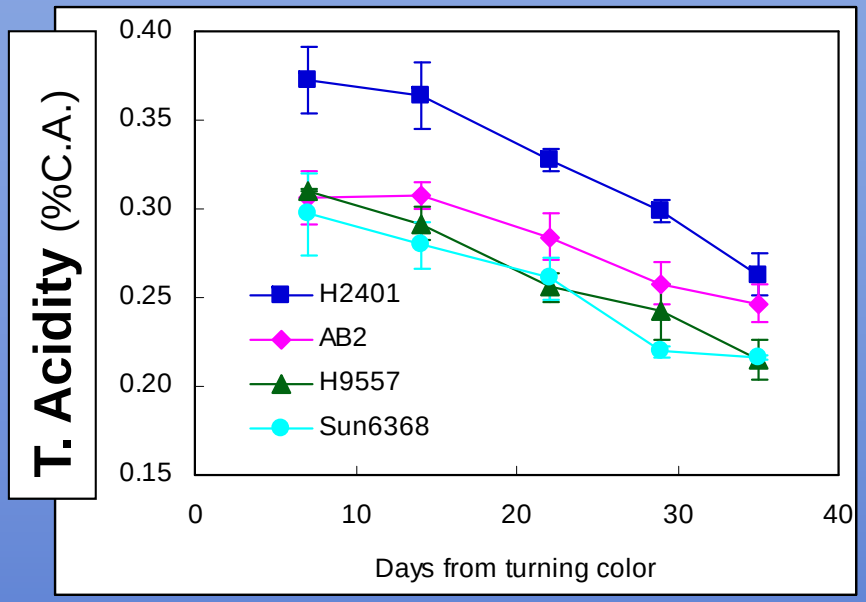
- Average pH increase with maturity
  - Fresno trial ~ 0.015 pH unit/day
  - Davis trial ~ 0.010 pH unit/day

- Historic PTAB data.
  - Overall ~ 0.008 pH unit/year
  - Individual varieties ~ 0.012 pH unit/year

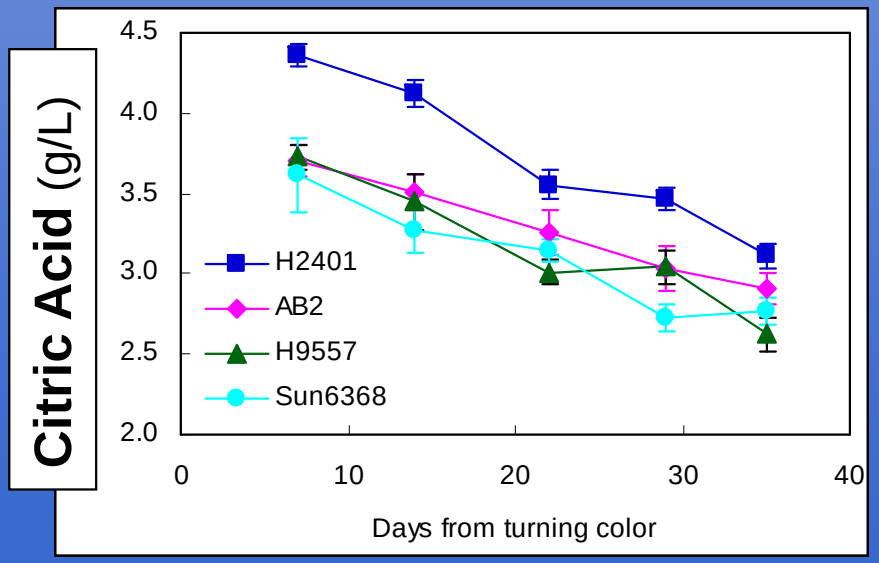
Increase in average maturity at harvest of only 1 day per year would account for historic trend.

RESULTS: Increase in pH and loss of citric acid

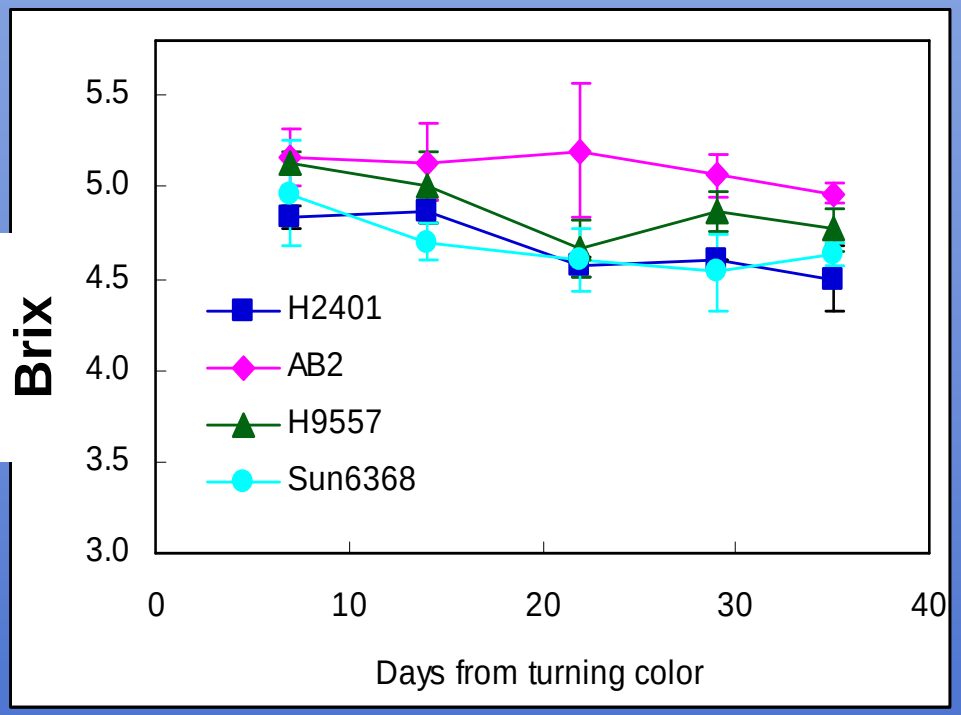


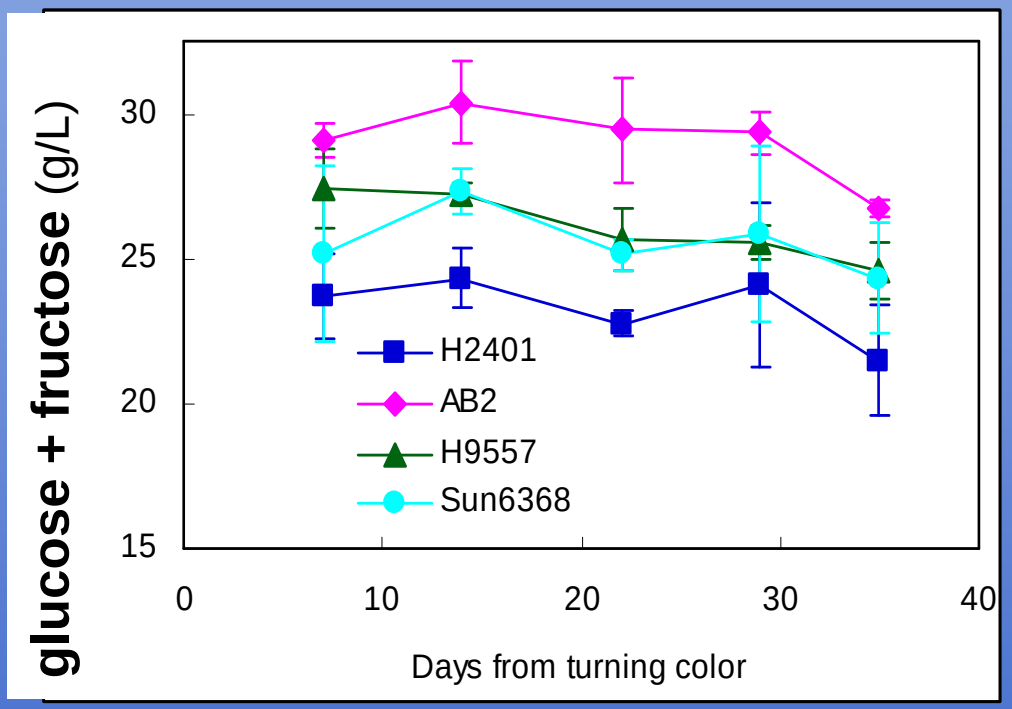


As pH increases, both Titratable Acidity and citric acid (primary part of T.A.) decrease.



RESULTS: Citric acid is not converted to sugars

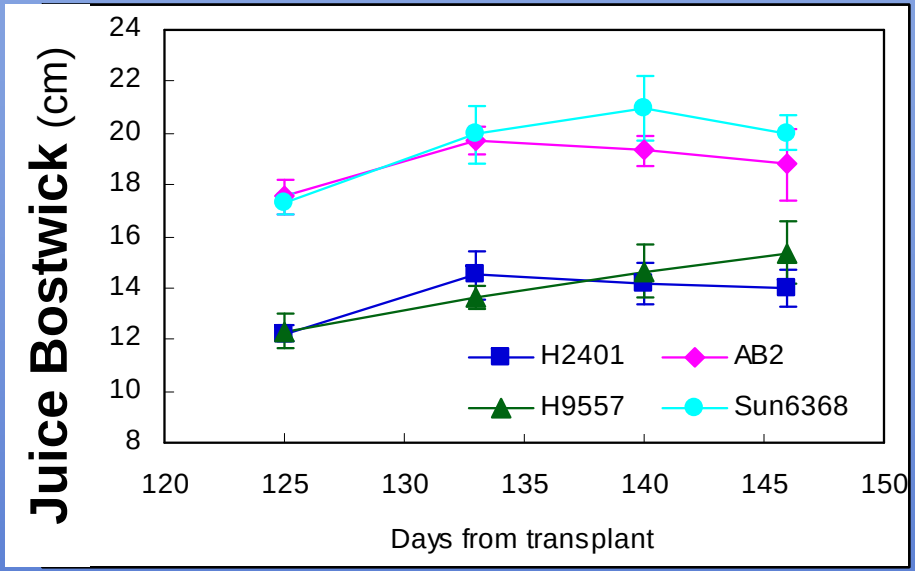




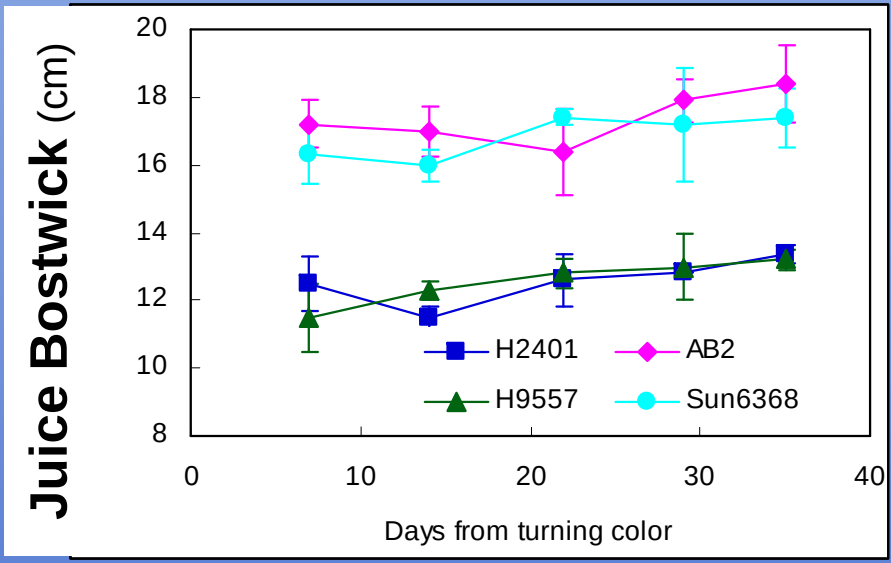
Citric acid goes down, but it is not converted to sugars.
Instead we believe it is used
as an energy source in the fruit and respired away.

RESULTS: Small increase in Bostwick, decrease in pectin

Fresno

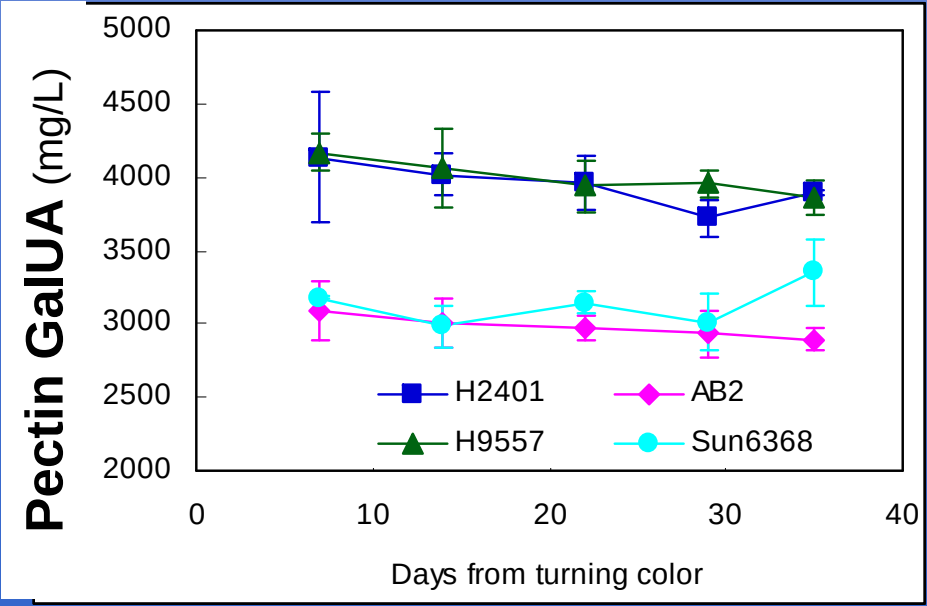


Davis



As maturity increases, viscosity decreases.

This is reflected in higher (runnier) Bostwick values and a decrease in pectin. Undesirable.



What about the effect of location and local growing conditions?

- Made use of 35 Ag Seeds field trials involving different growing conditions in different locations throughout the state.
- Grew the same six varieties at each:

APT 410, AB2, N6366, N6368, H2401, H9557

- Brix and pH analysis conducted by Ag Seeds.

Ag Seeds Field Trials

Location	Plant Date	Sample Date	Days	Irrigation	Planting Method	Average pH	Average Brix
Colusa	2-Apr	5-Aug	125	Drip	Transplant	4.41	5.36
Colusa	20-Apr	24-Aug	126	Furrow	Seeded	4.35	5.35
Fresno	13-Mar	22-Jul	131	Drip	Transplant	4.56	5.41
Fresno	25-Mar	18-Aug	146	Furrow	Seeded	4.45	5.84
Kern	30-Mar	27-Jul	119	Drip	Transplant	4.52	5.93
Kern	13-Mar	12-Aug	152	Furrow	Seeded	4.35	6.10

Slightly higher pH in

Drip fields using Transplants vs. Furrow irrigated fields using Seed.

Recent changes in production practices may also affect pH.

Conclusion: It is the Maturity of the Fruit!

Solutions:

1. Breed for higher acid, lower pH, especially in EFS varieties e.g. H2401.
2. Add citric acid during processing.

   Calculate to lower juice pH 0.1 unit requires about 0.3 lbs citric acid per ton tomato

3. Modify break process:

   Use cold-break to create more acidity.

Thank you!

Are there any questions?

Acknowledgements:

CA League of Food Processors

CTRI

UCD Food Science Lab

UC WSREC