Project Title: **UCCE Statewide Processing Tomato Variety Evaluation Trials, 2013**

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Summary:

University of California Cooperative Extension farm advisors, in cooperation with commercial growers and CTRI, conducted five mid-maturity variety evaluation trials in 2013. Seed companies submitted 13 replicated lines and 18 observational entries for the mid-maturity/full-season trial.

Among varieties in the replicated trials, HM 1892, H 1175, H 5608 and N 6407 were highest yielding, while H 1161, AB 0311, N 6402, N 6407 and SUN 6366 were highest in soluble solids. There were few yield differences in the observational variety trials, while soluble solids were highest from HMX 2898, BQ 311, H1285, BQ 296 and UG 16609. Variety yield varied by trial, highlighting the importance of looking at results from the individual trials to gauge variety performance under different conditions.

Objectives:

The major objective of our project is to evaluate pre-commercial and early commercial release processing tomato varieties for fruit yield, soluble solids, color, and pH in replicated field trials conducted at multiple locations statewide. The data are combined from multiple trials to evaluate variety adaptability under a wide range of growing conditions. These tests are designed and conducted with input from seed companies, processors, and other allied industry members and are intended to generate third-party information on varieties to assist in decision-making.

Procedures:
Five mid-maturity/full-season variety evaluation trials were conducted in 2013. Details of the trials are presented in Table 1. Variety selections were made in November of 2012 with input from California tomato processors. Changes and/or additions were made by the seed companies based on seed availability. Table 2 lists the variety entries, their disease resistances and other characteristics as provided by the seed companies. New varieties are generally evaluated for one of more years in non-replicated observational trials before moving forward for evaluation in the replicated trials.

Test locations were transplanted over an 11-day period from April 30th to May 10th. This year all the trials were conducted in commercial production fields with grower cooperators. Each variety was planted

in a single-bed plot measuring 30 to 100 feet in length, depending on the trial location. Both double and single row plots were utilized, again depending on location (see Table 1). Experimental design of each trial was a randomized complete block with four replications. The observational trial consisted of single plots of each variety planted adjacent to the replicated trial. The farm advisor organized transplanting at the same time that the rest of the field was planted. All cultural operations, with the exception of planting and harvest, were done by the grower cooperator using the same equipment and techniques as the rest of the field. All locations used transplants and all but one used drip irrigation.

Shortly before or during harvest (dates in table 1), fruit samples were collected from each plot and submitted to a grading station run by the Processing Tomato Advisory Board (PTAB) for measurement of raw fruit quality including soluble solids (°Brix, an estimate of the soluble solids percentage using a refractometer), color (LED color), and fruit pH. These samples consisted of ripe fruit picked from the vines or pulled off the harvester. Additionally, fruit samples were analyzed for cooked fruit quality by the lab of Diane Barrett at UC Davis with funding from the California League of Food Processors; results of those analyses are not reported here but are available from Dr. Barrett. For yield data, the plots were harvested with commercial harvest equipment, conveyed to a GT wagon equipped with weigh cells, and weighed before going to the bulk trailers for processing. The exception to this was the Stanislaus trial which had shorter plots of which a 20-sq ft section was harvested by hand.

Yield and fruit quality data were subjected to analysis of variance using the SAS software package. When data were combined from multiple locations, the block effect was nested within each county. Mean separation tests were performed using Fisher's protected LSD at the 5% level. The Merced trial was missing yield data from one or more plots, therefore least-squares means are reported rather than arithmetic means. At the Fresno location, variety N 6407 was not planted.

Results:

Replicated trials of mid-maturity/full-season varieties were conducted at five locations; results of analyses combining all locations are shown in Table 3, and results of individual trials in Tables 4 – 7.

Combining all trials together for analysis, the varieties varied significantly for yield and all fruit quality measurements. However, there was also a significant variety by location interaction for yield, meaning that varieties yielded somewhat differently depending on the trial location. Therefore, the reader should use some caution when viewing the combined results (Table 3), and may find it more informative to look at the results of individual trials (Tables 4 to 7).

Mean yield of the combined trials was 56 tons per acre, with a range of trial averages from 48.9 (San Joaquin) to 59.5 tons per acre (Stanislaus). Variety HM 1892 ranked first overall with a mean of 62.5 tons per acre; but its rank was first only at the Stanislaus location. At other locations, first-ranked varieties were H 1175 (Colusa and Fresno) and H 5608 (San Joaquin and Merced). See Table 4.

Overall, the soluble solids averaged 5.5 °Brix when data were combined from all trials, with trial averages varying from 5.1 to 5.7 °Brix (see Table 5). Top performers overall were H 1161, AB 0311, N 6402, N 6407 and SUN 6366. However, at particular locations, other varieties made it into that top group (for example, H 1170 at Colusa and San Joaquin, N 6404 at Colusa and Fresno). The leaders for Brix-yield (tons per acre x °Brix) were HM 1892, H 1161 and N 6407.

The Fresno County trial had the best fruit color overall (average of 21.1). Best fruit color was observed in varieties SUN 6366, H 5608, H 1175, H 1170, AB 031, and N 6402, with LED color measurements averaging 21.3 to 22 (Table 6). Fruit pH of varieties ranged from 4.29 to 4.48 (mean = 4.39, Table 7), with lowest means for H 8504, HM 1893, and H 1161.

Mid observational. Mid-maturity/full-season varieties which are new to our trial program were evaluated in single plots at five locations. Results of analyses combining five of these locations are shown in Table 8. While the average yields of varieties ranged from 36.9 to 57.7 tons per acre, varieties in the top ten ranks were are considered to have statistically similar yield. Because these varieties are not replicated within a trial location, we do not know if the variation in performance by location is due to the particular conditions of that location or due to experimental error (random factors not of interest). When all trials were combined for analysis, significant differences were found among varieties for °Brix, color, and pH. Varieties with the highest soluble solids were HMX 2898, BQ 311, BQ 296 and H 1285 (5.8 to 6 °Brix). Those with the best color included H 1292, H 1293, HMX 3907, HMX 2897 and N 6412 (measurements of 20 to 21.2). Fruit pH was lowest in UG 16609, BQ 296 and N 6410 (pH of 4.34 to 4.35).

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Table 1. 2013 Statewide Processing Tomato Variety Trial details.

County	San Joaquin	Fresno	Colusa	Stanislaus	Merced
Trial coordinator	Brenna Aegerter	Michelle Le Strange	Chuck Rivara	Scott Stoddard	Scott Stoddard
transplant date	30-Apr	7-May	8-May	9-May	10-May
fruit sampling for T-4 cooked analysis	3-Sep (126 days)	16-Sep (132)	13-Sep (128)	not sampled for T-4 project	9-Sep (122)
PTAB fruit sampling	3-Sep (126 days)	16-Sep (132)	13-Sep (128)	10-Sep (124)	25-Sep (138)
harvest date	4-Sep (127 days)	17-Sep (133)	18-Sep (133)	10-Sep (124)	25-Sep (138)
field variety	H 9663	H 2401	H 8504	DRI 0319	HM 9905
irrigation method	furrow	drip	drip	drip	drip
bed configuration	single row 60"; ~7500 plants/acre	single row 66"; 16" spacing	60"	double row 66"	double row 80"
Cooperator & location	Del Terra Farms, S. Bird Rd., SE of Tracy	Scott Schmidt, Farming D, Five Points	Lucero Farms, SE corner of Myer & Lone Star, Williams	Cox & Perez, Hwy 33 and N. Hamilton Rd, N. of Westley	Aric Barcellos, A-Bar Ranch, Russell Ave, Los Banos
plot length	100 ft	100 to 110 ft	100 ft	35 ft (hand-harvested)	90 ft
notes	15-20% Curly top			Curly top and TSWV	

Table 2. Varieties evaluated in 2013: information provided by seed companies.

TRIAL	VAR	COMPANY	UC code	days to maturity	Disease Resistance	processed use	Brix	std compared	vine size	fruit shape	UC trial years
REPLICATED	AB 0311	Monsanto	1017	118	VFFNP SW	Multiuse	5.6	AB2/6366	med-lg		11,12, 13
	AB 2 (STD)	Monsanto	868	122	VFFP	Multiuse	5.3		med	sq	standard since '05
	H 1161	Heinz Seed	1038	125	VFFNP	thin/multiuse	5.8	AB2	lg	oval	12, 13
	H 1170	Heinz Seed	1039	128	VFFN	thick/multiuse, EFH	5.3	H 9780	lg	blocky	12, 13
	H 1175	Heinz Seed	1040	130	VFFN	paste, EFH	4.9	H 9780	V lg	blocky	12, 13
	H 5608	Heinz Seed	987	128	VFFNP SW	MultiUse	5	H9780	V. lg	blocky	10, 11, 12, 13
	H 8504 (STD)	Heinz Seed	972	130	VFFNP	thick, EFS	high		med	oval	09, 10, 13
	HM 1892	Harris Moran	1041	122	VFFNP	Multiuse, EFH	high	H3402	lg	elong. sq	12, 13
	HM 1893	Harris Moran	1030	116	VFFN SW	multiuse/solids	med			elong. sq	13
	N 6402	Nunhems	1027	122	VFFNP SW	solids/multiuse	5.6-5.7	AB2/6366	lg	blocky	12, 13
	N 6404	Nunhems	1026	125	VFFNP SW	multiuse, EFH	5.3-5.4	H 8504	med-lg	blocky	12, 13
	N 6407	Nunhems	1043	130	VFFNP SW	solids, EFH	5.5-5.6	6368/ H 8504	med-lg	blocky	12, 13
	SUN 6366 (STD)	Nunhems	919	118	VFFNP	Multiuse	high		med	sq/blocky	04 to 13
OBSERVATIONAL	BQ 295	Woodbridge Seeds	1047	120	VFFNP SW	inter visc	high		med		13
	BQ 296	Woodbridge Seeds	1048	122	VFFNP SW	inter visc	high		med		13
	BQ 311	Woodbridge Seeds	1049		VFFNP SW						13
	BQ 313	Woodbridge Seeds	1050		VFFNP SW	thick	hiigh				13
	C 322	Harris Moran	1051	122	VFFNP SW	multiuse, thick	med		med	elong. sq	13
	C 324	Harris Moran	1052	120	VFFNP SW	multiuse, solids	high		med	elong. sq	13
	HMX 2897	Harris Moran	1053	122	VFFNP SW	multiuse, inter visc	med/hi		lg	elong. sq	13
	HMX 2898	Harris Moran	1054	125	VFFNP	multiuse, EFH	high		lg	elong. sq	13
	HMX 3907	Harris Moran	1055	122	VFFFN	multiuse, med/thick	med/hi		med	elong. sq	13
	HMX 3908	Harris Moran	1056	122	VFFN SW	multiuse, med/thick	med/hi		med		13
	H 1285	Heinz Seed	1057	130	VFFNP SW	inter visc			lg		13
	H 1292	Heinz Seed	1058	115	VFFNP SW	pear			med-lg		13
	H 1293	Heinz Seed	1059	120	VFFNP SW	pear			med-lg		13
	ISI 31060	ISI Sementi	1060		VFFNP SW	Peel	5.2	AB 0311	med	oval	13
	N 6410	Nunhems USA	1061	130	VFFN	viscosity, EFH	5.2-5.4	H 8504	med-lg	blocky	13
	N 6412	Nunhems USA	1062	116	VFFFNP Lv	solids/multiuse	5.3-5.4	CX 282	med	blocky	13
	UG 16609	United Genetics	1063	120	VFFNP SW	multiuse/thick	high	SUN 6366	lg		13
	IVF 5268	Gaoyong	1064	135	VFFNP	paste		SUN 6366	med	blocky	13

Disease resistance traits anticipated by seed companies, check with seed company to confirm.
V = Verticillium Wilt race 1
FF = Fusarium wilt races 1 & 2, FFF = races 1 & 2 & 3
N = Root knot nematode
P = Bacterial speck race 0
SW = Spotted Wilt
Lv = Leveillula taurica (powdery mildew)

Table 3. Replicated varieties, combined analysis of five replicated trials, 2013.

Variety	plots (#)	Yield (tons/acre)		rank	Soluble solids (°Brix)		rank	Color		rank	pH		rank
HM 1892	19	62.5	a	(1)	5.4	de	(5)	22.8	de	(10)	4.41	de	(7)
H 1175	19	60.2	ab	(2)	4.9	g	(9)	21.4	ab	(2)	4.48	g	(12)
H 5608	19	59.5	abc	(3)	5.1	fg	(7)	21.3	a	(1)	4.43	ef	(9)
N 6407	14	58.3	abcd	(4)	5.7	abc	(3)	24.2	f	(12)	4.34	bc	(4)
H 1161	19	57.0	bcde	(5)	5.9	a	(1)	23.1	e	(11)	4.33	ab	(3)
H 8504	19	56.5	bcde	(6)	5.0	g	(8)	22.3	bcde	(6)	4.29	a	(1)
N 6404	19	55.8	cde	(7)	5.6	bc	(4)	22.4	cde	(7)	4.42	de	(8)
N 6402	19	55.3	de	(8)	5.7	abc	(3)	22.0	abcd	(5)	4.44	efg	(10)
AB 0311	19	54.7	def	(9)	5.8	ab	(2)	21.9	abcd	(4)	4.35	bc	(5)
H 1170	19	54.3	def	(10)	5.6	cd	(4)	21.6	abc	(3)	4.38	cd	(6)
AB 2	19	53.6	efg	(11)	5.4	de	(5)	22.5	cde	(8)	4.35	bc	(5)
HM 1893	19	50.9	fg	(12)	5.3	ef	(6)	22.7	de	(9)	4.32	ab	(2)
SUN 6366	19	49.9	g	(13)	5.7	abc	(3)	21.3	a	(1)	4.47	fg	(11)
Mean		56.0			5.5			22.2			4.39		
CV=		11.4			6.5			6.8			1.5		
LSD @ 0.05=		4.07			0.23			0.96			0.041		
LSD @ 0.05= to compare N 6407 with other varieties		4.74			0.26			1.12			0.048		

Numbers in parentheses are the relative ranking of each variety within a column.
LSD = Least significant difference at the 95% confidence level. Means followed by the same letter are not significantly different.
CV = coefficient of variation (%), a measure of the variability in the experiment.

Table 4. Yield of replicated varieties overall and by trial location.

Variety	plots (#)	Yield 5 locations (tons/acre)		Colusa	San Joaquin	Stanislaus	Merced	Fresno
HM 1892	19	62.5	a	64.6	52.7	71.6	63.7	62.1
H 1175	19	60.2	ab	66.2	51.7	54.8	63.1	63.8
H 5608	19	59.5	abc	62.0	54.3	57.1	66.7	56.6
N 6407	14	58.3	abcd	60.4	51.7	66.9	55.6	---
H 1161	19	57.0	bcde	61.7	55.1	58.5	49.5	60.4
H 8504	19	56.5	bcde	60.7	45.1	62.6	53.7	62.0
N 6404	19	55.8	cde	53.4	50.9	56.3	65.2	53.5
N 6402	19	55.3	de	55.7	50.9	56.5	59.7	54.1
AB 0311	19	54.7	def	53.4	47.8	62.2	58.2	53.5
H 1170	19	54.3	def	54.7	39.4	58.1	59.5	60.8
AB 2	19	53.6	efg	45.8	48.2	58.0	68.0	49.2
HM 1893	19	50.9	fg	52.5	43.8	57.3	52.9	49.4
SUN 6366	19	49.9	g	45.4	43.5	53.2	51.6	56.5
	Mean	56.0		56.6	48.9	59.5	59.1	56.8
	CV=	11.4		9.3	8.4	10.7	14.9	9.1
	LSD @ 0.05=	4.07		7.51	5.87	10.72	12.58	7.44
	LSD @ 0.05= to compare N 6407 with other varieties	4.74						

LSD = Least significant difference at the 95% confidence level. Means followed by the same letter are not significantly different.
CV = coefficient of variation (%), a measure of the variability in the experiment.

Table 5. Soluble solids of replicated varieties overall and by trial location.

Variety	plots (#)	Soluble solids (°Brix) 5 locations		Colusa	San Joaquin	Stanislaus	Merced	Fresno
H 1161	19	5.9	a	5.4	6.2	5.9	6.0	6.0
AB 0311	19	5.8	ab	5.3	6.2	5.6	6.1	6.0
N 6402	19	5.7	abc	5.1	6.0	5.9	5.6	6.3
N 6407	14	5.7	abc	5.2	5.8	6.0	5.9	---
SUN 6366	19	5.7	abc	4.9	5.9	5.4	5.9	6.3
N 6404	19	5.6	bc	5.3	5.8	5.9	5.3	6.0
H 1170	19	5.6	cd	5.4	6.1	5.2	5.5	5.6
HM 1892	19	5.4	de	5.2	5.7	5.0	5.3	5.7
AB 2	19	5.4	de	5.1	5.7	5.6	4.9	5.7
HM 1893	19	5.3	ef	5.1	5.4	5.2	5.1	5.6
H 5608	19	5.1	fg	4.6	5.4	5.1	5.1	5.1
H 8504	19	5.0	g	4.8	5.4	4.8	4.9	5.3
H 1175	19	4.9	g	4.8	5.1	4.9	4.6	5.2
Mean		5.5		5.1	5.7	5.4	5.4	5.7
CV=		6.5		3.5	4.0	5.4	11.3	4.0
LSD @ 0.05=		0.23		0.25	0.33	0.49	0.87	0.33
LSD @ 0.05= to compare N 6407 with other varieties		0.26						

LSD = Least significant difference at the 95% confidence level. Means followed by the same letter are not significantly different.
CV = coefficient of variation (%), a measure of the variability in the experiment.

Table 6. Color of replicated varieties overall and by trial location.

Variety	plots (#)	Color 5 locations		Colusa	San Joaquin	Stanislaus	Merced	Fresno
SUN 6366	19	21.3	a	22.0	21.5	21.7	20.8	20.5
H 5608	19	21.3	a	21.0	20.5	22.3	22.0	21.0
H 1175	19	21.4	ab	20.8	20.0	23.3	23.3	20.3
H 1170	19	21.6	abc	21.8	20.5	22.3	22.0	21.5
AB 0311	19	21.9	abcd	22.3	22.3	23.0	20.5	21.8
N 6402	19	22.0	abcd	23.0	22.5	23.3	21.8	19.8
H 8504	19	22.3	bcde	22.5	22.8	22.0	22.3	22.0
N 6404	19	22.4	cde	23.3	23.0	23.0	22.3	20.8
AB 2	19	22.5	cde	22.3	21.8	22.3	24.0	22.3
HM 1893	19	22.7	de	23.0	22.0	22.7	23.8	22.0
HM 1892	19	22.8	de	23.3	23.8	23.7	22.5	21.3
H 1161	19	23.1	e	25.3	22.8	22.7	22.8	21.8
N 6407	14	24.2	f	25.3	24.5	25.0	21.7	---
	Mean	22.2		22.7	22.1	22.9	22.3	21.2
	CV=	6.8		3.3	5.4	3.6	11.2	4.4
	LSD @ 0.05=	0.96		1.08	1.73	1.39	NS	1.35
	LSD @ 0.05= to compare N 6407 with other varieties	1.12						

NS = Not significant.
LSD = Least significant difference at the 95% confidence level. Means followed by the same letter are not significantly different.
CV = coefficient of variation (%), a measure of the variability in the experiment.

Table 7. pH of replicated varieties overall and by trial location.

Variety	plots (#)	pH 5 locations		Colusa	San Joaquin	Stanislaus	Merced	Fresno
H 8504	19	4.29	a	4.25	4.21	4.30	4.31	4.38
HM 1893	19	4.32	ab	4.27	4.22	4.34	4.34	4.44
H 1161	19	4.33	ab	4.26	4.22	4.31	4.36	4.48
N 6407	14	4.34	bc	4.35	4.30	4.31	4.42	---
AB 2	19	4.35	bc	4.31	4.27	4.32	4.42	4.41
AB 0311	19	4.35	bc	4.33	4.24	4.34	4.43	4.41
H 1170	19	4.38	cd	4.40	4.31	4.30	4.37	4.50
HM 1892	19	4.41	de	4.38	4.34	4.38	4.43	4.51
N 6404	19	4.42	de	4.35	4.36	4.42	4.46	4.52
H 5608	19	4.43	ef	4.37	4.34	4.37	4.46	4.57
N 6402	19	4.44	efg	4.46	4.34	4.37	4.46	4.56
SUN 6366	19	4.47	fg	4.47	4.41	4.34	4.51	4.58
H 1175	19	4.48	g	4.48	4.39	4.48	4.52	4.54
Mean		4.39		4.36	4.30	4.35	4.42	4.49
CV=		1.5		1.03	0.94	1.20	1.58	1.45
LSD @ 0.05=		0.041		0.064	0.058	0.088	0.100	0.094
LSD @ 0.05= to compare N 6407 with other varieties		0.048						

LSD = Least significant difference at the 95% confidence level. Means followed by the same letter are not significantly different.
CV = coefficient of variation (%), a measure of the variability in the experiment.

Table 8. Processing tomato varieties evaluated in 2013 observational trials. Observational varieties are planted in only a single plot at each location; data presented are the means of five locations.

Variety	plots (#)	Yield (tons/acre)	rank	Soluble solids (°Brix)	rank	Color	rank	pH	rank
HMX 2897	5	57.7 a	(1)	5.3 fgh	(8)	21.2 ab	(3)	4.46 cd	(9)
H 1293	5	57.4 a	(2)	5.5 bcdefg	(6)	20.8 ab	(2)	4.50 def	(12)
N 6410	5	56.7 a	(3)	5.4 cdefgh	(7)	23.4 f	(12)	4.35 ab	(2)
UG 16609	5	53.4 ab	(4)	5.7 abcde	(4)	21.6 bcd	(5)	4.34 a	(1)
BQ 296	5	52.4 abc	(5)	5.8 abc	(3)	22.8 cdef	(9)	4.35 ab	(2)
N 6412	5	52.2 abc	(6)	5.6 abcdefg	(5)	21.2 ab	(3)	4.43 bcd	(7)
H 1285	5	51.6 abc	(7)	5.8 abcd	(3)	21.8 bcde	(6)	4.38 abc	(3)
H 1292	5	51.5 abc	(8)	5.5 bcdefg	(6)	20.0 a	(1)	4.56 f	(14)
C 322	5	51.5 abc	(8)	5.1 gh	(10)	21.4 abc	(4)	4.41 abc	(6)
HMX 2898	5	49.4 abc	(9)	6.0 a	(1)	23.2 ef	(11)	4.35 ab	(2)
BQ 313	5	49.2 abc	(10)	5.6 abcdef	(5)	21.6 bcd	(5)	4.49 def	(11)
HMX 3908	5	47.2 bc	(11)	5.0 h	(11)	21.6 bcd	(5)	4.40 abc	(5)
C 324	5	46.8 bc	(12)	5.3 efgh	(8)	21.8 bcde	(6)	4.45 cd	(8)
HMX 3907	5	44.9 bcd	(13)	5.2 fgh	(9)	21.2 ab	(3)	4.40 abc	(5)
BQ 295	5	44.8 cd	(14)	5.4 defgh	(7)	22.2 bcdef	(8)	4.47 cde	(10)
ISI 31060	5	44.7 cd	(15)	5.0 h	(11)	23.0 def	(10)	4.55 ef	(13)
IVF 5268	5	44.0 cd	(16)	5.6 abcdefg	(5)	21.6 bcd	(5)	4.39 abc	(4)
BQ 311	5	36.9 d	(17)	5.9 ab	(2)	22.0 bcdef	(7)	4.40 abc	(5)
	Mean	49.6		5.5		21.8		4.43	
	CV=	13.5		6.9		5.3		1.5	
	LSD @ 0.05=	8.45		0.48		1.47		0.086	

Numbers in parentheses are the relative ranking of each variety within a column.
LSD = Least significant difference at the 95% confidence level. Means followed by the same letter are not significantly different.
CV = coefficient of variation (%), a measure of the variability in the experiment.