University of California Cooperative Extension Processing Tomato Cultivar Evaluation Program

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SUMMARY. University of California Cooperative Extension farm advisors have conducted applied research to quantify processing tomato [*Lycopersicum esculentum* (L.) Mill] varietal performance, as a coordinated activity, since 1973. Early and midseason maturity varieties are annually evaluated at four to six locations throughout the state. The test varieties are selected in collaboration with seed companies, processors and growers. The growers and seed companies provide financial support for the tests. Most tests are conducted in production tomato fields and are harvested using commercial harvesters. The results are widely disseminated through an annual report to the funding sources, farm advisor research reports, newsletters, production meetings, the *California Tomato Grower* magazine, and popular media. The information obtained for fruit yield potential, fruit quality and plant horticultural characteristics is used by processors, growers, and seed compa-

nies to make variety selection decisions. This regional extension program has proven to be an effective way to generate well-designed replicated information for making intelligent processing tomato cultivar decisions and has been well accepted by the California industry.

California leads the United States in the production of processing tomatoes. More than 260,000 acres (105,000 ha) of processing tomatoes were grown in California in 1997, resulting in >10.6 million tons (9.6 million t) of fruit being produced (California Agricultural Statistics Service, 1998). This was 92% of the total U.S. processing tomato acreage and 94% of the fruit production. The average yield of 38.2 tons/acre (85.7 t·ha⁻¹) was the highest in the United States (California Agricultural Statistical Services, 1998). The California processing tomato crop had a total on-farm value of \$608 million in 1996, making it the single highest value processing vegetable crop produced in the state (California Agricultural Statistical Services, 1997).

The key word in California agriculture is diversity, which would be expected in a state that stretches 1000 miles (1610 km) between the Mexican and Oregon borders. Differences in climate, soil texture, soil quality and local production practices are significant and impact performance of each variety differently. Tomato production in California occurs from the Imperial Valley (latitude 32°N) to Colusa (latitude 39°N) and from the central coastal regions to the San Joaquin and

Sacramento Valley interiors. These areas differ in rainfall, maximum and minimum air temperatures, soil types and fertility, and water quality and availability. This suggests that some regions would be better suited for specific varieties or final processing tomato products.

More than 175 different processing tomato varieties were commercially produced in California in 1997. The counties leading production were Fresno (36%), Yolo (19%), San Joaquin (10%), Colusa (8%), and Sutter, Solano, Stanislaus, and Merced (4% to 6% each). Collectively, these eight counties accounted for >93% of the entire crop (California Agricultural Statistics Service, 1998). The varieties 'Halley 3155' and 'Heinz 8892' represented >48% of the total production (Rivara, 1997). An additional 48 additional varieties, however, made up the bulk of the remaining delivered harvest (45%), illustrating the need for a coordinated neutral effort to sort through the array of varietal choices.

A program was initiated in 1973 to address this need. Farm advisors from Fresno, San Joaquin, and Yolo Counties banded together to conduct the first cooperative processing tomato variety evaluation. At that time, most of the state's production was located in those three areas. Since then, the industry has expanded, taking advantage of environmental niches, spreading the risk of crop failure across greater acreage and providing additional options for tomato rotation. Today, farm advisors in six to

Fig. 1. Harvested acreage of processing tomatoes in California, 1973–97.

Farm advisors, University of California Cooperative Extension, Colusa, Sutter/Yuba, Contra Costa, Fresno, Yolo/Solano, San Joaquin, Stanislaus, and Merced Counties, respectively.

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Fig. 2. Average processing tomato yields in California, 1973-97.

Fig. 3. Total California processing tomato production, 1973-97.

eight of the major production areas conduct annual variety evaluations. Figures 1 through 3 illustrate how the California processing tomato industry has changed during the time period of this statewide evaluation program.

Materials and methods

OVERVIEW. The objective of the University of California (UC) Statewide Processing Tomato Variety Evaluation Trials is to evaluate a common group of new or recently released varieties, under uniform methods, in multilocations. Separate tests are conducted for both early maturity and mid

to late maturity cultivars. Within each of these tests, four replications of each line are grown in randomized plots and a group of observational varieties are grown in single plots. The observational varieties are typically experimental lines or material close to commercial release for which limited data is available. The trial is an opportunity to screen them across a wide range of environmental or growing conditions. Those varieties that look promising in the observational plots, and that processors or seed companies deem appropriate, are advanced to the replicated stage. The program attempts to evaluate replicated varieties for three

years, unless there are compelling reasons to extend the evaluation period. The tests also include two industry standards, selected on the basis of previous trial data.

VARIETAL SELECTION. The test varieties are selected after extensive discussions and interactions with the industry. These discussions begin in the late fall, with a meeting of the UC researchers and commercial processor managers. The results of the previous year's trial program are reviewed. Advice on which varieties to continue in the program and which to drop is given, based on each processor's raw product needs and the regional performances of each variety. Processors also identify additional varieties to test, from preliminary information received from seed companies or from their own internal variety evaluations.

The UC researchers communicate with seed companies operating in California and share the results of the processor discussions. Seed availability for desired varieties is determined and the seed companies suggest additional varieties for testing that were not previously identified by the processors.

PROJECT FUNDING. There are two sources of funding for this work. The first is an annual grant from the California Tomato Research Institute, Inc. (CTRI). This grower group voluntarily assesses itself to generate monies to support applied research in processing tomatoes. They contribute about \$6,000 to the project annually. The money pays for fruit samples, obtained from each variety at each location, to be analyzed for soluble solids and juice color by the grading stations of the Processing Tomato Advisory Board. CTRI also provides periodic funding for the construction or maintenance of specialized equipment used to obtain fruit yield data.

The second source of funding is provided by participating seed companies. An entry fee of \$100 per replicated variety and \$50 per observational variety is requested for each test location. This money is provided to the farm advisors conducting tests and is used to hire temporary field assistance, purchase materials and equipment, and support travel associated with developing or delivering trial information.

Although no actual monies change hands, the cooperating growers also provide significant support by providing test sites, equipment and crop management. They also accommodate data

Table 1. University of California farm advisor early maturity 1997 processing tomato variety trial data for replicated varieties. Combined data from five locations (Colusa, Fresno, San Joaquin, Stanislaus, and Yolo Counties).

Variety	Yield (tons/acre) ^z	°Brix ^y	°Brix × yield (tons/acre) ^x	Blended juice color ^w
CXD 171	45.8	5.2	2.37	25.1
Sun 6235	45.7	5.0	2.28	24.9
Red-Set-Go 28	44.9	4.5	2.02	25.0
H 3044 ^v	43.5	4.3	1.87	23.4
BOS 8066	43.4	4.3	1.86	24.3
RPT 1108	43.2	4.7	2.03	26.4
APT 266	41.9	5.1	2.14	24.4
FMX 1071N	41.9	4.6	1.93	26.9
PX 16313	41.9	4.7	1.97	27.5
CXD 187	41.7	4.6	1.92	24.2
HyPeel 45	41.0	5.4	2.21	25.8
APTX 410	40.8	4.9	2.00	23.8
Sun 6117	40.3	5.0	2.02	24.8
FMX 1080N	40.0	4.7	1.86	26.9
H 9280 ^v	36.2	4.2	1.52	23.8
LSD _{0.05}	3.3	0.2	0.18	1.0
CV (%)	10.5	6.0	12.1	6.1
Mean	42.1	4.7	1.99	25.1
Variety × location (LSD _{0.05})	13.7	0.4	0.7	NS

^w1 ton/acre = 2.24 t·ha⁻¹.^xPercent soluble solids. Composite fruit sample, mixed in a blender under vacuum.^yYield × °Brix, 1 ton/acre = 2.24 t·ha⁻¹.^zComposite fruit sample, mixed in a blender under vacuum. The lower values are more intense red than larger values.^vStandard varieties.^{ns}Nonsignificant.

collection by facilitating harvest schedule slowdowns. Processors, in turn, cooperate by accepting loads of mixed fruit.

PLANTING THE TESTS. The test sites are approximately one acre in size and are located within larger production fields. Plots 100 ft (30 m) long are typically used at each site. Every attempt is made to treat each site uniformly across locations. Fresh, viable seed lots are obtained from the seed companies and sublots are sent to each location advisor. Seed weights are obtained, and approximately the same number of seeds are planted in each plot at each site. The cooperating grower plants the entire field with his equipment, except for study plots. In the premarked plot areas, the planter chains are disconnected and the planters apply preplant fertilizer to the plots without dropping seed. Using the marks left by the planter packing wheel to indicate row placement, the plots are then seeded at an appropriate soil depth with a hand-push planter. Other than planting and harvesting, all of the cultural operations are conducted by the grower and are the same as the larger production field. Notes are taken during the growing season by the location advisor and include: emergence

dates, final plant stands, seedling vigor, and growing conditions. Varietal differences for disease resistance or tolerance are also recorded.

SAMPLING THE FRUIT. The plots are sampled 1 to 3 d before the field being harvested. All of the fruit are removed from several randomly selected plants in each plot. Fruit are separated into red, green immature, and cull categories. These categories are weighed to obtain fruit maturity information. A sample of 30 to 50 marketable fruit [5.5 to 6.5 lb (2.5 to 3.0 kg) depending on fruit size] is taken to a state grading station for soluble solids and color determinations. All loads delivered to processors must go through a privately operated station to pass inspection requirements and determine baseline fruit quality information. Soluble solids are determined with a temperature-compensated, hand-held, refractometer (model 10423; American Optical Corp.). Color determinations are made with a LED tomato color meter developed by the UC, Davis, Biological and Agricultural Engineering Department.

HARVESTING THE PLOTS. Test sites are harvested at the same time as the rest of the larger production field, using the

grower's harvester and crew. The 100-foot-long plots are harvested and all the fruit on the belts and chains are run through the machine. The harvester is stopped at the end of each plot and the fruit is routed into a hydraulic dumper gondola equipped with load sensing bars. A digital read out of the weight is obtained and fruit yields per acre are calculated. The harvest trailer gondolas have a capacity of 8,000 to 10,000 lb (3,625 to 4,535 kg) of fruit, so they must be periodically emptied into commercial bulk trailers as harvest of the test proceeds. The harvest trailers were provided to the farm advisors with funding from the CTRI. The quality and quantity of the fruit from the plots should approximate the real-world situation, as a commercial harvester and crew are used.

ANALYZING THE DATA. A biometrician is contracted to analyze the data from the various test sites. The data are evaluated for main effects of the variety, site or location effects and interactions of locations and varieties.

REPORTING THE RESULTS. Information from the statewide trials is extended to end-users in a variety of ways. First, field days are held at the test sites within 2 to 3 weeks of harvest. Growers,

Table 2. University of California farm advisor midmaturity 1997 processing tomato variety trial data for replicated varieties. Combined data from five locations (Colusa, Fresno, San Joaquin, Sutter, and Yolo Counties).

Variety	Yield (tons/acre) ^z	°Brix ^y	°Brix × yield (tons/acre) ^x	Blended juice color ^w
HyPack 159	52.1	4.6	2.39	23.3
CXD 188	51.3	5.0	2.56	21.3
AB 4077	49.9	5.1	2.55	21.9
H 8892*	48.6	4.8	2.33	22.4
H 9492	48.5	5.0	2.43	22.2
Sun 6229	47.9	5.0	2.39	23.9
CXD 181	47.7	4.9	2.34	23.4
CXD 189	45.6	4.6	2.10	23.4
PX 6514	45.3	5.1	2.31	23.8
HyPeel 322	44.9	5.0	2.24	23.5
Halley 3155*	44.3	5.3	2.35	23.8
CXD 179	44.2	5.2	2.30	22.7
HMX 5887	43.1	5.1	2.20	23.3
HMX 487800	42.5	4.9	2.08	24.1
BOS 20/20	42.4	5.0	2.12	23.2
Sun 6216	42.3	4.9	2.07	22.2
RPT 1294	41.5	5.0	2.07	22.3
LSD _{0.05}	2.8	0.2	0.15	0.9
CV (%)	9.8	6.2	10.7	6.6
Mean	46.0	5.0	2.28	23.0
Variety × location (LSD _{0.05})	6.3	0.4	0.34	NS

^w1 ton/acre = 2.24 t·ha⁻¹.

^xPercent soluble solids. Composite fruit sample, mixed in a blender under vacuum.

^yYield × °Brix, 1 ton/acre = 2.24 t·ha⁻¹.

^zComposite fruit sample, mixed in a blender under vacuum. The lower values are more intense red than larger values.

*Standard varieties.

NSNonsignificant.

processors, seedsmen and other interested persons, are encouraged to attend and make their own observations on plant architecture, fruit maturity, fruit set and additional variables of interest.

An annual edition of the trade magazine *California Tomato Grower* is dedicated to research reports from UC farm advisors. This magazine reaches most of the people interested in the California processing tomato industry. The variety test conditions and results are always a part of this edition. Participating advisors prepare a detailed report of their individual test, as well as the state summary, and mail it to their local processing tomato clientele. A summary of the statewide trials is prepared for CTRI and published in their annual report. Many advisors summarize their variety results in their county newsletters, which reach additional clientele. The advisors also provide the test results at regional commodity meetings held each winter.

Results and discussion

1997 TESTS. Tables 1 and 2 report the results of the 1997 early and midmaturity cultivar evaluations. They

contain fruit quality and yield information for the five locations participating in the 1997 evaluations. The data has been analyzed to show differences due to both varieties and locations.

The Uniform Regional Processing Tomato Variety Evaluation Program conducted by UC farm advisors has proven to be an effective way to test the many new releases from private seed breeders every year. It is an industry-driven effort that involves recipients from the planning through the reporting phases. The resultant information is disseminated in many ways and is used by producers and processors to make research-based intelligent varietal selection decisions.

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