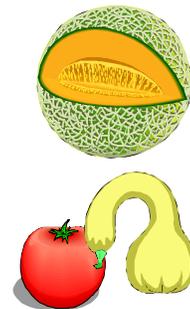




VEGETABLE CROP FACTS

Merced and Madera County



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SPECIAL EDITION: Processing Tomatoes in the San Joaquin Valley

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INTRODUCTION

Michelle Le Strange, Farm Advisor, Tulare & Kings Counties

Processing tomatoes are one of the state's most important crops in value and acreage. California accounts for about 90% of total U.S. production and 50% of world production. This industry is also one of the largest, most dynamic and most complex in CA agriculture, and like many ag commodities it is currently facing some issues that will impact its future.

While the industry has expanded considerably in the past 20 years, serious threats to CA competitiveness continue to increase. In recent years operation costs are higher due to labor, energy costs and regulatory compliance, which decrease profit margins. The CA advantage has been a dependable supply of high quality fruit coupled with high yields, but productivity is improving among world producers. A number of processing plants in northern CA have closed or moved southward into the San Joaquin Valley.

A goal of UC Cooperative Extension is to assist industry to improve production efficiency and product quality. Farm advisors and specialists conduct research projects in many facets of production, pest management, and postharvest quality and offer educational programs via industry meetings, field days, and workgroup activities. The processing tomato workgroup within UC Ag and Natural Resources (ANR) has been active in addressing a multitude of industry concerns for many years, one of which is the annual variety evaluation program. Varieties are compared side-by-side at multiple sites as part of a statewide program with input from university personnel, processors, and seed companies. The CA Tomato Research Institute, CA League of Food Processors, Processing Tomato Advisory Board, CA Tomato Growers Association and the Processed Tomato Foundation support UC programs. We encourage industry to continue participating in these organizations to keep CA competitive in a global market.

This newsletter was compiled to provide information to the processing tomato industry in the South San Joaquin Valley. If you have specific questions, please call one of your local Farm Advisors.

Processing Tomato Acreage, Average Yield, and Value in California

	1980			2000		
	Acres	Tons/A	\$ mil	Acres	Tons/A	\$ mil
Fresno	34,880	30.5	50.7	115,000	40.2	235.8
Kern	5110	24.5	6.0	7400	40.0	17.8
Kings	839	26.6	1.1	9969	47.0	19.0
Merced	6750	30.0	11.9	15,600	38.3	31.5

CA	203,294	27.2	274.5	297,631	38.1	572.9
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Within Row Plant Spacing in Processing Tomatoes

Gene Miyao, Farm Advisor, Yolo, Solano & Sacramento Counties

DIRECT SEEDED TOMATOES:

Tomatoes yield well over a wide range of plant populations. Direct seeded plants are very opportunistic in compensating for thin as well as thick stands. Field evaluations demonstrate maximum yields are achievable with plants spaced from 6 to 18 inches apart. In a few trials, yields did not plummet even when spaced 30 inches apart. A target of 9 inches between clumps has been an aim for most growers.

This benchmark does not need strong adherence. As the price of seed increases, movement toward lower plant populations by seeding toward final stand targets of 10 to 12 inches would not compromise yields. During prime planting periods, local variety trial evaluation of stand counts indicates emergence is approximately 50% of seeded rates. Unfortunately, the distribution of seedling emergence is not uniform, thus complicating formulating an optimal seeding rate.

The primary economic justification for seeding at a high rate is to overcome obstacles such as: poor weather conditions during emergence, soil crusting, losses to insects, diseases and bird feeding, frost and hail. During the expected poor weather conditions, high seeding rates help buffer against thin stands. While high seeding rate plantings don't guarantee an adequate stand, it helps.

Bottom Line: Final stands of 1 to 3 plants per clump spaced any where between 8 to 15 inches between clumps could be a target under many situations. A final stand of 12 inches between clumps is a conservative goal. With double seed lines per bed, the distance between plants can be increased over that of single seed lines per bed.

Clumps of plants yield slightly more than similarly spaced stands thinned to singles. Conversely, once a stand is established, only those fields with seedlings crowded with about 8 or more plants per foot in a single seed line should be candidates for thinning.

TRANSPLANTED TOMATOES:

What is the ideal distance to transplant plugs down the row? While the answer would be filled with many qualifiers (soil quality, variety selection, time of year, field history, etc.), field tests conducted in Yolo County in the mid 80's suggested that transplants did not compensate for lower plant populations as well as direct seeded plants. Based on these few tests, the recommended transplant spatial target was less than 20 inches between plugs. Most growers in the area first began transplanting to 12 inches and many gradually increased the distance to 15 to 16 inches between plugs. Later, some growers opted to spread their transplants across a double-'seed' line configuration.

Transplant Spacing Study: With renewed interest a transplant spacing study was conducted in 2001 in the western part of Yolo County near the town of Madison. The grower cooperater was Blake Harlan of Harlan and Dumars. The soil type was a class 2, Tehama loam. The variety, Halley 3155, was planted on March 30th using the grower's mechanical transplanting equipment and crew. Plants were placed on single lines per bed centered on 5 feet. The field was initially irrigated with sprinklers for a single time and thereafter with furrows.

The spatial treatments were distances between transplanted plugs ranging from 8 to 28 inches apart in 4-inch incremental steps (8, 12, 16, 20, 24 and 28 inches). Individual plots were planted in a single row for the entire field length, approximately 1/2 mile long. The trial design was a randomized complete block with 6 replications. The trial area was composed of 36 beds (6 treatments x 6 reps). After planting, the study area was confined to 3 consecutive 200-foot sections of each row near the headland in order to more easily monitor the plants and manage the harvest.

Over the course of the season, an average of 4% of the plants was killed, mainly to root rot. The loss of plants was uniform across treatments, but the resulting 'bare-ground' gaps between plants were higher in the low population treatments. In the wide spacing, the accumulated gap averaged less than 3 feet over a 200-foot distance.

Results: Ten days before mechanical harvest, a 10-foot length of each row was hand harvested to assess fruit maturity. Fruit were separated into categories of red, pink or green by weight. Fruit size as estimated by weighing a batch sample of 50 red fruit. There were no statistically significant differences among the treatments for percent pink or green fruit (Table 1).

Table 1. Influence of transplant population on pre-harvest fruit maturity of variety Halley, 2001.

The grower mechanically harvested the plots into GT carts equipped with weigh sensors to measure yields on August 16th. Yields were higher in plots with wider spacing between plugs (Figure 1), positively correlated to increased spatial distance. Soluble solids and fruit color were reduced slightly with the wider spacing while pH was unaffected (Table 2). For soluble solids and color, the plug spacing of 16 to 20 inches produced similar quality to the closer spacing treatment. Mold levels were elevated with closer spacing. As expected, fruit 'size' was increased with the wider spacing.

Summary: Placing plugs 12 inches apart and closer is costly at both ends of the season: initial higher investment in plants and lower yield at harvest. While it would be very bold to recommend that transplants be spaced over 2 feet between plants,

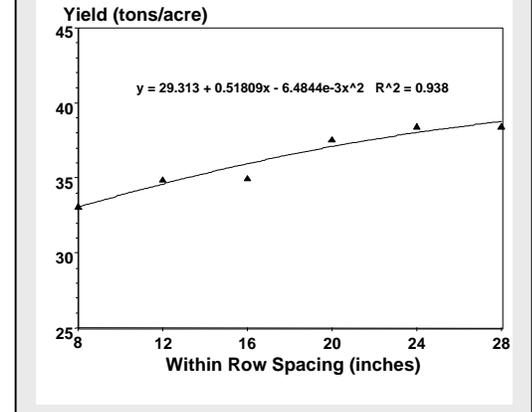
Table 2. Influence of transplant population on yield and quality of variety Halley, 2001.

Transplant Spacing	Yield tons/acre	Color	°Brix	pH	% sunburn	% mold	Lbs. per 50 fruit
8"	33.1	23.7	5.5	4.31	7	13	7.6
12	34.9	24.3	5.4	4.31	6	12	8.1
16	35.0	24.1	5.4	4.30	7	11	8.2
20	37.6	24.2	5.5	4.31	7	10	8.5
24	38.4	24.9	5.3	4.30	6	8	8.6
28	38.4	24.9	5.3	4.30	6	8	8.7
Probability	0.02	0.03	0	NS	NS	0.003	0

a more conservative transplanting strategy should be adopted from our research results. Growers should be comfortable with transplanting to distances at or slightly above 15 inches between plants.

This field research effort will continue with funding support for the 2002 season through the California Tomato Research Institute (CTRI).

Figure 1. Influence of plant spacing on yield of processing tomato variety Halley.



Mixing Anti-Crusting Agents with Pre-emergence Herbicides: Effects on Stand Establishment and Weed Control

Kurt Hembree, Farm Advisor, Fresno County

Soils that tend to seal over or crust following planting by seed and sprinkler irrigation can lead to a significant decline in plant stand establishment and yield. While there has been research conducted looking at various "anti-crusting" agents, little information is known on the influence of mixing pre-emergence herbicides with these agents.

A study was conducted in 2001 to determine the impact of combining anti-crusting agents with Shadeout® on stand establishment and nightshade control in processing tomatoes. A grower's field was selected in western Fresno County that had a history of soil crusting and poor tomato stands. Plots were established in April and measured 3 beds-wide and 600' long. Five pre-emergence treatments were included in the study, replicated 4 times each. The treatments were applied in a 12" band over the seeded row. The treatments included Shadeout® alone at 2 oz/acre and Shadeout® tank-mixed with N-Cal Platinum® (20 gpa), phosphoric plus N-phuric acid (6 gpa each), and Thiocal (40 gpa). Untreated plots were also

included in the study. All treatments were applied with a 3-row sprayer that delivered the spray in 50 gpa.

Processing tomatoes were planted on April 6 and the treatments were applied. Over-head sprinkler irrigation was used to incorporate the treatments within 3 days of treatment. No yields were determined in the study.

Tomato stand was significantly improved over all the other treatments when N-Cal Platinum® was added to the herbicide as a tank-mix partner (See table). There was an average of 1 tomato plant emerged every 2", compared to 1 plant every 4" in plots not receiving any anti crusting materials. The other anti-crusting agents did not fair much better than the untreated. The degree of soil crusting was evaluated visually to see how much effort was required to break through the soil surface. Soil in the N-Cal treatment appeared flocculated, with little to no evidence of sealing over. All other treatments varied in the degree of hardness of the soil surface and were

fairly difficult to break through. Black nightshade control was best where Shadeout® was applied alone or with the N-Cal treatment. The use of acid and Thiocal treatments led to reduced nightshade control. It is known that Shadeout® activity is adversely affected by acidity, thus explaining the poor control.

While this work is preliminary, it appears that certain anti-crusting agents can be tank-mixed with Shadeout® following

planting direct-seeded tomatoes to improve stand while maintaining weed control. It also appears that acid-based anti-crusting agents have an adverse effect on the activity of Shadeout®. Further studies need to be conducted to determine the influence of these and similar anti-crusting agents on stand establishment. Hopefully, this will lead to the reduction in the amount of seed needed to achieve a desired stand in soils that tend to crust.

Table 1: Tomato and weed stand on 4/30/01 following crop emergence.

Treatment	Rate/Acre	No. tomatoes/ 10' of row	No. nightshade/ 10' of row	Soil crust rating*
1. Shadeout	2.0 oz	26.7 c	10.7 d	4.5 a
2. Shadeout	2.0 oz	49.5 a	9.5 d	1.0 c
N-Cal Platinum	20.0 gal			
3. Shadeout	2.0 oz	33.5 b	46.5 c	3.5 ab
N-phuric acid	6.0 gal			
Phosphoric acid	6.0 gal			
4. Shadeout	2.0 oz	24.5 c	60.2 b	3.3 b
Thiocal	40.0 gal			
5. Untreated		26.7 c	107.5 a	4.5 a
Statistical notation at p=0.05		(CV): 9.95%	12.80%	17.23%
		(LSD): 6.3	11.8	1.1

*Based on a scale of 0 to 5; 0 = no observed crusting and 5 = severe crusting

Early Season Irrigation of Processing Tomatoes

Tim Hartz, Extension Specialist, UC Davis

In my experience, irrigation management is a crucial part of processing tomato production; more potential yield is lost due to improper water management than to any other factor that a grower can control. Here is some background information on early season irrigation management; elsewhere in this newsletter are some suggested practices for preharvest irrigation management to maximize fruit quality.

It is important to begin the season with a full soil moisture profile. Tomatoes are deeply rooted, capable of drawing water from as deep as four feet or more. However, once the tomatoes are established and actively growing it becomes increasingly difficult to irrigate sufficiently to replenish deep moisture without overirrigating and inducing Phytophthora root rot or fruit rots. Therefore, with the combination of pre-irrigation and sprinkler irrigation to establish the plants, enough water should be applied to thoroughly wet the profile. The crop should start out with a full bank account.

Although tomatoes will tolerate significant moisture stress with minimal visual symptoms on the vine, early season water stress can reduce yield potential and increase the incidence of blossom end rot on fruit.

It is difficult to condense all the issues involved with effective irrigation into a newsletter article; a good overall reference on irrigation scheduling is 'Scheduling Irrigation: When and How Much', which can be purchased from the UC Web site at <http://anrcatalog.ucdavis.edu/>. This manual has a full discussion of evapotranspiration, crop coefficients, soil moisture monitoring techniques, etc.

The one message that I would underscore here is that until fruit set is complete, no more than half of the available moisture in the top 2 feet of soil should be depleted between irrigations. The only good way to evaluate soil moisture depletion is through direct monitoring.

The old 'feel' method of determining soil moisture is quick and easy, but less quantitative than using one of the monitoring tools available. Several high-tech devices have come on the market in recent years, but for cost-effectiveness and ease of use I prefer electrical resistance blocks. The most widely used resistance block is probably the Watermark™ block. These blocks are calibrated in centibars (cb) of soil moisture tension. Fifty percent available moisture depletion is equivalent to about 40-50 cb in sandy soils, and 60-90 cb in heavier soils. In practical terms, maintaining at least 50% of available soil moisture in the top two feet of soil usually means irrigating approximately every 7-14 days (depending on weather conditions and soil texture) once the plants begin to set fruit. The water intake rate of some soils slows

dramatically over the course of the season, so on some irrigations you may get less recharge of the root zone than you expect. Soil moisture monitoring is the only way to be sure you are successfully maintaining deep soil moisture.

Once fruit set is complete (usually about 6-7 weeks before harvest) it is desirable to induce some moisture stress to increase fruit soluble solids. At this point soil moisture stress will not cause additional blossom end rot, but can marginally reduce the average fruit weight, which will reduce yield; it is a balancing act to achieve soluble solids high enough to satisfy the processor while keeping yield loss to a minimum.

Fertilizer Guidelines for Processing Tomatoes

Gene Miyao, Farm Advisor, Yolo, Solano, & Sacramento Counties

Fertilization application rates vary widely among California tomato growers. Typical seasonal application rates are 125 to 250 pounds of nitrogen per acre, 60 to 120 pounds of P₂O₅ per acre and 0 to 120 pounds of K₂O per acre. Soil tests are valuable to provide background levels of soil fertility especially for P, K and zinc.

Nitrogen: University research has shown that under normal conditions, maximum yield can be obtained with approximately 140 to 180 pounds of N per acre. N applications as a sidedress at or prior to layby of 120 to 150 pounds are very sufficient. Recent studies by Veg Crops Specialist Jeff Mitchell demonstrated that soils with over 16 ppm nitrate-N in the top foot prior to sidedressing did not respond to additional N applications beyond that supplied as a starter fertilizer. Luxuriant levels of N are not necessary.

Phosphorus: Soils with bicarbonate-extractable phosphorous greater than 12 to 15 ppm are unlikely to respond to P application, although a temporary early growth response to preplant P may be seen in early spring conditions. An early seedling growth response can favorably result in earlier maturity. Below 12 ppm, a yield response to applied P would be expected.

Potassium: Many California soils have adequate potassium for high yield tomato production. However, on soils with ammonium-acetate-extractable K less than 150 ppm, K applications may be required; seasonal rates would vary from 60 to 150 pounds of K₂O per acre.

Zinc: If zinc is limiting, (below 0.3 ppm), supplemental applications in the starter fertilizer or higher rates broadcast are recommended. Above 0.5 ppm, no additional zinc is recommended.

Starter Fertilizer: Placement of the starter fertilizer is important. A band 1 to 2 inches directly below the seed is

best. Since initial roots grow directly downward, placement of the fertilizer to the side will delay pickup. Fertilizer located 2 inches to the side of the seed line is not efficient. Mechanics of fertilizer placement may be a concern. Disturbance of the seedbed by a fertilizer knife ahead of the planter can affect ideal seed-to-soil contact. Offsetting the knife 1/2 inch to the side of the seed line or angling the knife from the side are techniques to reduce disturbance of the seed line when attempting to plant without supplemental moisture for emergence. Placing the seed in direct contact with conventional fertilizers will result in poor germination and/or delayed emergence.

Pop-up applications are special techniques for suboptimal conditions where soils may be too wet to effectively place fertilizer below the seed. Starter fertilizer placement as a band below the seed is the superior method especially in low phosphorus soils and cool temperatures. Pop-up starter fertilizer application at rates of 11 gpa per seed line of a solution of 1 gallon of 10-34-0 diluted with 5 gallons of water is an alternative supplemental application method in fields still too wet to shank in starter at higher rates below the seed. On-seed application rates should be low so as not to create salt hazards that can inhibit germination. Some delay in rate of emergence and reduction in stand has occurred with the on-seed fertilizer application. The yield gain as well as seedling growth benefit will offset the stand reduction if phosphorus is needed. Higher rates and exotic blends with various pesticides should be avoided with on-seed placement. Leaving nontreated check strips are highly recommended.

For transplants, the conventional preplant rates fit into the program. Placement would be deeper and could be offset to the side slightly to reach developing roots growing out of the root ball. While not exact, maintaining dilute solutions of a material like 10-34-0 at rates of 8 gallons per 400 gallons of water per acre are reasonable when fertilizing with the transplant water. Solutions with K salts should be avoided.

Fertilizer Timing: Regardless of irrigation technique, most P is applied preplant, usually in a banded application. Where drip irrigation is used, N and K (if needed) are applied in numerous small fertigation throughout the season. In conventionally irrigated fields, N and K (if needed) are applied preplant and in one or more sidedress applications. Supplemental foliar feeding of N, P and K have had little economic benefit and impact on processing tomato production.

Summary: Even in 1979, the respected UC Cooperative Extension processing tomato team of Bill Sims, Mel Zobel, Don May, Bob Mullen and Phil Osterli realized in their numerous field tests “there would have been few crop failures

even if only starter fertilizers had been applied.” In general the soils in our Central Valley are fertile. For profitable tomato production, a little starter fertilizer and a moderate level of sidedress N are sufficient. Our production system is not bottlenecked due to lack of applied N.

Potassium Requirements for Processing Tomatoes

Tim Hartz, Extension Specialist, UC Davis

Paste to Peel: The California processing tomato industry has traditionally been focused on the production of bulk paste, for which the primary fruit quality factors were blended color and soluble solids content. However, changes in the marketplace over the last decade (increasing sales of salsa and ‘chunky’ sauces, for example) have dramatically increased the need for whole, peeled fruit.

Yellow Eye and White Streak: A major quality issue for peeled fruit is color uniformity. A fruit color disorder called ‘yellow eye’, in which a ring of tissue around the stem scar remains yellow upon ripening, is a widespread problem. Yellow eye can range in severity from just a narrow halo of yellow around the stem scar, to the entire shoulder area of a fruit remaining yellow. When the peel is removed, the extent of yellow tissue is usually larger than was evident externally.

An associated problem is the presence of veins or streaks of white tissue that can occur throughout the fruit. Together these color disorders can be severe enough to prevent whole production fields from being used for peeled, diced products.

Survey of 140 Fields: A project was conducted to determine the cause of these color disorders, and to develop management practices to minimize their occurrence and severity. County Farm Advisors Kent Brittan, Mike Cahn, Gene Miyao, Bob Mullen, Mike Murray, and Jesus Valencia, together with Veg Crop Specialist Jeff Mitchell and I conducted a statewide survey of 140 commercial tomato fields to determine if soil fertility characteristics and fruit quality were correlated.

K, Mg and Yellow Eye: The survey showed a clear relationship between exchangeable soil potassium (K), and the ratio of exchangeable soil K to magnesium (Mg), and these color disorders. Unlike the Sacramento Valley, where high soil Mg is a common problem, soil Mg levels in Fresno,

Kings, Tulare, and Kern Counties are generally moderate to low. In these counties the occurrence and severity of yellow eye and internal white tissue can be predicted mainly by the level of exchangeable soil K. Soils in which K makes up at least 3% of cation exchange are likely to produce good fruit color uniformity. Table 1 lists the minimum exchangeable soil K level to meet this 3% rule for various soil textures.

K and Yield: In addition to fruit color issues, soil K level can also affect yield, and perhaps soluble solids. From 1994 to 1998 a total of 16 field trials were conducted to evaluate the effect of K application rate and application technique on processing tomato yield, soluble solids, and blended color. The results were very consistent. In 2 of 3 trials in which the soil had < 130 PPM exchangeable K, yield was increased with K fertilization; not one of the 13 trials in which soil K > 130 PPM showed a significant yield increase. In no field did K fertilization increase soluble solids or blended color.

In six of these field trials the effect of K fertilization on the fruit color disorders was also determined. The occurrence or severity of yellow eye and internal white tissue was reduced by K fertilization in 4 of these fields, but the amount of improvement was modest, and fertilizer application in excess of 400 lb K₂O per acre was required to obtain a significant response.

Summary: Given this background, my advice to processing tomato growers in the southern San Joaquin Valley is:

- 1) K fertilizer application in fields with soil exchangeable K < 130 PPM may be necessary to ensure maximum yield; fields with more available K are unlikely to show a yield increase with K fertilization. K fertilization rates of 50-150 lb K₂O per acre are appropriate in fields with exchangeable K between 100-130 PPM, while rates as high as 250-300 lb K₂O per acre may be justified in fields with

very low K. Regardless of initial soil K level, do not expect K fertilization to result in increased soluble solids content or blended color score; these quality characteristics are controlled mainly by factors other than soil fertility.

- 2) If you are growing tomatoes destined for peeling, plant them in fields with high soil K, ideally at least

as high as the levels suggested in Table 1. This is no guarantee of freedom from the color disorders, but it is the most reliable way to maximize peeling quality. Although heavy K fertilization can reduce yellow eye and internal white tissue, it is not likely to be cost effective unless you are paid a substantial premium for high peeling quality.

Table 1. Predicted minimum soil exchangeable K required for optimum tomato fruit color uniformity.

Soil texture	Minimum exchangeable K (PPM)*
Sandy loam	130
Loam	180
Clay loam	230

* top 12 inches of soil

How Much “N” to Sidedress: Try a PSNT

Henry Krusekopf, Jeff Mitchell, Tim Hartz, Don May, Gene Miyao & Michael Cahn

Excessive nitrogen (N) application is an economic loss to growers in terms of unnecessary input costs, and may also result in greater pest management problems. From an environmental perspective, overuse of chemical nitrogen fertilizer has been associated with increased levels of nitrate-nitrogen (NO₃-N) in ground and surface water. For these reasons, development of a better system for recommending fertilizer rates is a major goal of agricultural research.

The largest N fertilizer input for processing tomatoes occurs at sidedressing when plants are 4 to 6 inches tall. Recommended sidedress N application rates are 120 to 180 lbs N/acre, but to ensure maximum yield growers typically apply 130 to 225 lbs.

PSNT: Research has shown a correlation between NO₃-N concentration in the top 12 inches of soil prior to sidedressing and crop yield response to sidedress N. The evidence suggests that a **Pre-sidedress Soil Nitrate Test (PSNT)** can indicate a critical level of soil NO₃-N above which crop yield will not be increased by subsequent sidedress N application. Although the PSNT method has not been widely used to determine specific sidedress N application rates for fields testing below a critical level, it has been found helpful at identifying fields where no sidedress N fertilizer is required to maintain yields.

Research Goal: The main objective of our research was to determine if the PSNT technique was useful for predicting the necessity of sidedress N fertilizer on a field-by-field basis in conventional processing tomato production in California.

Ten Tomato Fields: The project was carried out at 8 commercial farms and 2 research stations in 1998-99. Tomato plantings followed standard crop rotations for the region and the individual grower’s cultural practices including pre-plant

and/or pre-sidedress N fertilization. Common hybrid tomato varieties were grown at all locations. All fields received a single sidedress application of urea at rates between 0 to 250 lbs N/acre in six increments (0, 50, 100, 150, 200, 250 lbs N/acre) when plant height was approximately 4 to 6 inches. Fertilizer was banded using a standard applicator to a depth of 6 inches, and at a distance of 6 inches from the plant row. All fields were furrow-irrigated and grown under typical practices.

Prior to sidedress N application, a PSNT was conducted at all sites to a depth of 12 inches. Soil cores were taken from shoulders of beds then immediately stored on ice to inhibit N mineralization until processed and analyzed for NO₃-N concentration. At harvest, fruit yields were determined by mechanically harvesting plots into a scale-equipped wagon. Samples of unsorted fruit were collected from the harvester from each plot for determination of fruit maturity and percent defects. Fifty red fruit from each plot were evaluated for soluble solids content – which included the degrees brix – and blended juice color. Relative fruit yield for each treatment was calculated by dividing the mean yield for each treatment by the mean of the highest yielding treatment in that field.

Yield Results: Of the 10 fields utilized in this study, only four fields had any significant yield response to sidedress N, and none of these fields demonstrated yield response to sidedress N application above 100 lbs N/acre. In fields eight, nine and ten the application of any sidedress N increased yield compared to unfertilized plots, but yields at 50 lbs N/acre were not significantly different to those achieved with higher fertilization rates. In field four, a significant yield increase was observed up to 100 lbs N/acre. There were no fields with yield response to sidedress N application that had pre-sidedress soil NO₃-N concentrations above 15.7 ppm.

Fruit Quality Results: Fruit maturity and quality parameters (% red, % rotten fruit, blended fruit color, and soluble solids content) were generally unaffected by N treatment in most fields. In field four, the unfertilized and the 250 lbs N/acre treatments showed the lowest color score – most intense red color – while intermediate N rate treatments had lower soluble solids content. In field eight, fruit soluble solids content decreased with increasing N rate.

Excessive N Rates: *This study showed that both university recommended and industry sidedress N application rates for processing tomato production in CA are excessive and could be substantially reduced without loss of yield or fruit quality.*

Critical Levels: The lack of yield response to sidedress N application in fields with NO₃-N at greater than 16 ppm prior to sidedressing was not surprising, since these soil nitrate nitrogen levels represented more than 60 percent of seasonal total N uptake (180 lbs N/acre) for high-yield tomato production. Pre-sidedress residual soil N in project fields was augmented by in-season N mineralization of soil organic matter, which could have provided an additional 35 to 70 lbs N/acre to plants during the growing season. Therefore, in-

season mineralization of organic N, coupled with existing soil NO₃-N estimated by PSNT, are likely factors in the overall weak crop response to sidedress N. A PSNT level greater than 16 ppm of NO₃-N in the top 1 foot of soil could represent a conservative threshold level for determining whether sidedress fertilization is required. This suggested PSNT threshold level for processing tomatoes is slightly lower than those determined for corn production in the Northeastern and Midwestern USA, and CA coastal valley lettuce and celery production. These studies generally set PSNT thresholds between 20 to 25 ppm NO₃-N.

Summary: These results support using a PSNT to identify processing tomato fields that are unlikely to respond to sidedress N application. Fields with concentrations greater than 16 ppm of NO₃-N in the top foot of soil have low probability of increased yields with sidedress N application. Furthermore, the limited response to sidedress N application, even in fields with minimal residual NO₃-N levels, suggested that sidedress N rates currently used by the commercial tomato industry could be substantially reduced with no loss of yield or fruit quality.

Early and Late Blight Diseases of Tomatoes

Joe Nunez, Farm Advisor, Kern County

Early blight and late blight are two serious disease problems of tomatoes. Although early blight is common on potatoes in Kern County, it appears to be a rare problem on tomatoes in California. Late blight has not been a major problem for the last few years because California has been experiencing dry, warm springs. But under the right conditions these two leaf blights can quickly become serious problems. Being aware of them may help prevent them from causing extreme economic damage.

Both diseases are leaf blights that reduce tomato yields by killing the leaf and stem tissue and in severe cases infecting the fruit. Under ideal conditions these leaf blights can cause complete crop loss. *Contrary to their names, early blight typically appears late in the growing season and late blight is usually found early in the season in the San Joaquin Valley.* In other parts of the world their names are more fitting. To add to the confusion, these two diseases also look similar even though they are opposite from each other in many ways. Therefore, it is essential to understand the similarities and differences of these two problems to effectively manage them.

Late Blight: Late blight is the more devastating of the two blights. It can spread across a field in a matter of days and cause substantial loss of fruit and vines when conditions are right. Mild temperatures, moist or humid conditions, and lush, dense canopies favor late blight development. These are conditions that are more common during the early to mid part of the crop cycle.

A water mold fungus, *Phytophthora infestans* causes late blight. *Phytophthora infestans* is typically favored by cool, moist conditions. However, in the last decade new strains of *P. infestans* have developed naturally, and they are active at higher temperatures and drier conditions than the old strains. These new strains have virtually replaced the old strains in most parts of the country, including the San Joaquin Valley. Currently strain US-11 is the most common on tomatoes in California. US-1 used to be the common strain, but now we no longer see it. Unfortunately, these new strains of *P. infestans* are resistant to menfenoxyan/metalaxyl (Ridomil), which had been very effective in the past for late blight control.

Late blight symptoms vary depending on environmental conditions. The typical conditions for late blight development are mild temperatures (65-75°F) and 100% RH. But the new strains of late blight are active on potatoes and tomatoes in mid-summer, even under rather dry conditions. Typically, the lesions begin inside the plant canopy as small irregular shaped dark spots on the leaves. These spots will expand rapidly if high humidity or moisture is present. The lesions become black as they enlarge and a grayish mass of spores will develop on the underside of the leaves. The new strains also seem to infect the stems more than the older strains. The symptoms are black irregular lesions on the stem that will expand and often kill the terminal end of the stem or branch. Fruit can also be affected by late blight. The fruit will develop a brown discoloration but stay rather firm.

The late blight pathogen must survive between crops on living host tissue. In California this may be on volunteer tomato and potato plants, unharvested potato tubers, or even susceptible weed hosts such as hairy nightshade. It may also be brought into a field on infected transplants. Infections begin when spores from transplants or blown into a field germinate and start the cycle of plant infection. If conditions are ideal, late blight can spread rapidly across a field. Under dry, warm conditions late blight may be limited to localized lesions. The latter was observed in several tomato fields in the summer of 2001.

Control of late blight includes removing any nearby volunteer tomato and potato plants and nightshade. If using transplants, check that they are free of late blight before planting. Excessive nitrogen and water can produce lush, dense, and humid canopies that are ideal for late blight development. Fungicides can be used if there is a concern, but only as a preventive treatment and not as a curative. If conditions are conducive for late blight and/or late blight has been reported in the area, the interval between applications should be shortened. Scouting fields on a regular basis is important for late blight management because of how quickly it can start and spread.

Early Blight: Early blight begins as small black spots on the older, lower leaves. As the lesions expand, they produce a visible series of concentric rings that give the lesion the appearance of a “bull’s eye” target. These lesions can also occur on the stems and fruit.

Early blight, caused by the fungus *Alternaria solani*, favors plants that are stressed, mature, or otherwise weakened. These conditions are more common towards the end of the crop season.

Early blight is able to survive on living hosts, on plant debris, or in the soil as spores. Again, volunteer tomato and potato plants should be destroyed. Proper crop rotation is important to insure that infected plant debris decomposes. Maintain good fertilization and irrigation practices to sustain the vigor of the plant until senescence. Fungicides are rarely needed on tomatoes for early blight control.

Consult the UC IPM tomato manual and pest management guidelines for more descriptions, photographs, and fungicide recommendations for either of these blight diseases.

Fusarium Diseases of Tomato: An Overview

Mike Davis, Extension Specialist, UC Davis

In 2001, tomatoes in all counties in the Central Valley and San Diego County were surveyed for Fusarium diseases. The survey results are listed in a table following this article. The range of these diseases has increased considerably in a few years.

Fusarium Wilt: Symptoms of plants suffering from Fusarium wilt include wilting and yellowing of individual branches and associated leaves. Sometimes only one branch or one side of the plant is affected, creating a yellow flag effect. Infected plants usually die. A dark brown discoloration extends far up the stem. Symptoms often first appear during fruit sizing. Fusarium wilt can greatly reduce yields in severely infested fields. The fungus overwinters and survives for many years in the soil as spores. Long distance spread is by seed, transplants, and soil on farm machinery. The disease is favored by warm weather. The fungus only infects tomato but exists as three races. Race 1 is widespread; Race 2 is common only in the Sutter Basin and south to San Joaquin County; and Race 3, once restricted to fields in the Sutter Basin, is spreading south.

Control of Fusarium wilt depends on the use of resistant tomato varieties. Resistant varieties are common for Race 1, and many are also resistant to Race 2. A few varieties are resistant to all three races. Limit the spread of infested soil by cleaning farm equipment. Avoid root knot nematode infestations since nematode feeding can overcome the plant

resistance to Fusarium wilt. Rotation out of tomatoes for several years reduces inoculum level, although Fusarium is long-lived.

Fusarium Crown and Root Rot: Foliar symptoms on plants with Fusarium crown and root rot include yellowing along the margin of the oldest leaves, followed by necrosis. Dry brown lesions develop in the cortex of the tap or main lateral roots. A necrotic lesion may also develop on the surface of the stem from the soil line to 4 to 12 inches (10 to 30 cm) above it. Internally, a chocolate-brown to reddish brown discoloration extends no more than 6 to 12 inches (15 to 30 cm) above the soil line. Infected plants may be stunted and wilted.

The disease can occur in any of the California tomato-growing regions, but its occurrence is uncommon. It occasionally causes serious problems in greenhouses. In the Central Valley it causes little economical damage, but by the coast, where the cool temperatures and high humidity favor the disease, it can be a serious problem. The fungus overwinters and survives for many years in the soil as spores. Long distance spread is by transplants and in soil on farm machinery. Spores are airborne in greenhouses. The host range of the pathogen includes some legumes, cucurbits, other solanaceous plants, and more.

Fusarium Foot Rot: Foot rot of tomato caused by *Fusarium solani* was first reported on the Queensland Coast of Australia

in 1975. In California, the disease was first reported in 1991 but was probably present since at least 1984 in Yolo County. Once confined to a few fields, the disease has spread significantly and continues to do so. Based on 2001 survey work, the incidence of foot rot in individual fields in Yolo County has been as high as 15%. Today, the disease is now found in most of the Sacramento Valley and has moved into several counties in the San Joaquin Valley.

Foot Rot Symptoms and Damage: Symptoms of foot rot include brown to reddish-brown lesions (about 1 to 2.5 cm long) of the cortex of the tap or main lateral roots with a discoloration of the stele extending 2 to 10 cm from the lesion. Root lesions usually occur within the top 30 cm of soil, and sometimes invade the crown. Affected plants are stunted with varying degrees of interveinal chlorosis, mottling, and necrotic spotting on young foliage (suggesting the production of a toxin in infected plants). Foliar symptoms may be similar to certain viruses (tomato spotted wilt or alfalfa mosaic). Flowers on symptomatic branches are often necrotic. In severely affected plants, the taproot or main lateral roots are completely girdled and the crown may be rotted. Although plants usually do not die, yields are often reduced. In Australia, all 30 commercial cultivars evaluated were susceptible. In that country the disease is apparently restricted to a few farms with poor drainage and is limited in the cool time of the year.

Control Methods: Fungicides and fumigants have been ineffective for the control of foot rot. Crop rotation is also ineffective since *Fusarium solani*, like many *Fusarium* species, has the ability to survive long-term in the soil as chlamydospores or as a saprophyte on the roots of weeds and other crop plants. Once infested, the soil may remain so for years, if not indefinitely.

Little information is available concerning foot rot epidemiology. Based on our growth chamber work, warm temperatures favor disease development (in contrast to what was reported in Australia). Like other soilborne diseases caused by soil inhabitants, there are few or no methods available for controlling the disease or eliminating the fungus from the soil. Thus, the only realistic long-term solution for managing the disease is through breeding and the development of resistant varieties. Because the disease was once limited to a few fields and disease incidence is small compared to the incidence of late blight, Phytophthora root rot, and some of the bacterial leaf spots, no concerted effort has been initiated to examine germplasm collections for resistance against this disease.

Currently, the only recommended control strategy is to limit spread of infested soil by cleaning equipment between fields.

Distribution of Fusarium diseases of tomato in California, 2001.

Disease	County
Foot rot	Sacramento, San Joaquin, Solano, Sutter, Stanislaus, and Yolo
Fusarium wilt race I	Widespread throughout the state
Fusarium wilt race II	Most counties in the Sacramento Valley and northern and central San Joaquin Valley
Fusarium wilt race III	Colusa, Sacramento, San Joaquin, Solano, Sutter, and Yolo
Fusarium root and crown rot	Merced, San Diego, and San Joaquin

Curly Top of Tomatoes

Jesús Valencia, Farm Advisor, Fresno County

Curly top virus is an insect-vectored disease affecting many vegetable crops but is especially troublesome in tomatoes and sugarbeets. Infections often result in poor plant stands and yield loss. Beans, cucumber, melons, peppers, spinach, squash, plus other crops and weeds, can be affected by curly top virus. Symptoms and virulence levels are different among the agronomic and weed species. Some plants carry the virus yet do not show symptoms or negative impact. Curly top virus does not survive in the soil or decomposed plant debris. It can only survive on live plant material, and it must be picked up by the leafhopper in order to be spread from plant to plant.

Sugarbeet Leafhoppers—the Vector: The beet leaf hopper (*Circulifer tenellus*) is the vector of curly top virus. It is small (1/8 inch long) and pale green to gray in color. The insect overwinters as an adult feeding on biennial weeds and perennial plants native to the western foothills of the San Joaquin Valley. In the spring, females lay eggs and the first generation soon hatches. New hatches do not come inoculated with the virus and must feed on infected plants to acquire the disease. However, once the virus is acquired, it can survive in the insect for life.

Rising temperatures eventually cause the host plants in the foothills to dry up, so leafhoppers migrate to the valley floor where they feed and infect crops with the virus. Leafhoppers are strong flyers and travel long distances in search of food. They efficiently transmit the curly top virus to susceptible crops from plant to plant and from field to field across the valley floor. The insect can only transmit the virus by feeding. When it probes and feeds in the plant phloem, the virus is passed on and distributed into the entire plant with carbohydrates moving in the phloem tissue. Adult sugarbeet leafhoppers are generally better transmitters of the virus than young nymphs because of their ability to fly long distances in search of food.

Curly Top Disease Symptoms: Once the leafhopper infects plants, the virus multiplies rapidly and symptoms appear 5 to 10 days after initial infection. The most recently developed leaflets start twisting and turn a yellowish color. Older leaves thicken, roll upward and become leathery with a pronounced purple venation. Plant growth declines and the vine is severely stunted by the virus. Fruit ripens prematurely leading to 100% yield loss of infected plants.

Insect Control and Disease Management: Controlling leafhoppers in the crop may not reduce the incidence of the virus, since the insects do not colonize tomatoes and new waves of leafhoppers keep coming into the field. Tomatoes are just a “pit stop” for leafhoppers on their search for more suitable hosts. Unfortunately, as they probe into the tomato to find out if they like it or not, virus transmission takes place. However, insecticide sprays can be important in minimizing

in-field virus transmission. Also, since the insects seem to prefer single, isolated plants, close spacing or multiple plants in the transplant plug may be a good control strategy.

Last year, transplanted tomato fields were more affected by virus than direct seeded fields. The reason for the difference between the two planting methods could lie in the total number of plants per acre. Direct seeded fields have more plants per acre. Closer plant spacing distracts leafhoppers from landing. When they do land and transmit the virus, there are more plants to survive the virus attack causing minimal impact on yield.

Increasing plant population in transplanted fields from April on could be a good strategy in reducing losses from the virus. However, control measures are only beneficial in years with high leafhopper/virus activity. Keep in mind that leafhopper populations build up during dry and mild winter weather conditions and are cyclical. Until we learn more about leafhopper behavior, it is difficult to predict how long cycles last or when they’ll repeat again.

Editor’s note: CDFA sponsors the Curly Top Virus Control Program which monitors leafhopper populations, treats the western foothills, and tracks leafhopper movement in the valley. A dry winter and spring rains are ideal for leafhopper and curly top virus. Movement to the valley floor is early this year. Informational bulletins are available and mailed to growers throughout the season. Call the CTVCP in Fresno (559) 445-5472 for information and to get on the mailing list.

Extended Field Storage of Processing Tomatoes

Don May, Farm Advisor Emeritus, Fresno County

The objective is to develop a strategy to improve yield of processing tomatoes during periods when high-sustained air temperatures occur and disrupt fruit set, resulting in lower yields to growers. The approach is to plant tomatoes so that fruit set occurs at more desirable temperatures and to test varieties for *extended field storage* (EFS).

Field Experiments in 2000: The EFS trials consisted of four varieties successful in previous trials and eight new potential varieties. There were two planting dates: March 17th and April 21st. All plots were machine harvested with a commercial crew. Harvest started August 8th for the March planting and August 30th for the April planting. Each trial was harvested four times:

- Harvest 1 - fruit was 85-90% ripe
- Harvest 2 - two weeks after harvest 1
- Harvest 3 - three weeks after harvest 1
- Harvest 4 - four weeks after harvest 1

Data: Red fruit from each plot was weighed with a GTO weight mounted dumpster. A five-gallon bucket of unsorted tomatoes was taken from each plot and hand graded for percentage red, green, broken, or rotten, and 50 red fruit were randomly taken for fruit weight. This 50 fruit sample was taken to PTAB for solids and color determinations. About 730 samples were collected from these trials. Additional fruit quality measurements included peeling, pH, brix, color and bostwick.

Results: The top yielding EFS varieties were two previously trialed varieties, H 9492 and H 9665, and two new varieties, H 9995 and H 9992, in both the March and April planting. The Heinz varieties selected for best EFS may not be the best for peeling. These trials show that Bos 3155, Bos 315, and Peto 303 all have good EFS yield for about three weeks. Since these varieties are the most susceptible to poor yields when temperatures are high at fruit set, growers who are required to grow them for peeling will benefit as much from EFS as they

will growing Heinz varieties for paste. The three varieties with highest % solids were CXD 199, Bos 315 and Bos 3155, but their yields were also lowest.

Summary of Results: Over three years, trials at West Side Research and Extension Center and grower plantings have shown that selected EFS varieties direct seeded no later than April 21 will give higher yields than late April or May plantings for a September harvest. The results also show that by planting as early as March 15, using EFS varieties, yields will also be higher for late August harvests.

The paste type varieties H 9492, H 9665 and two new ones, H 9992 and H 9995, field stored one month. Peeling type varieties, Bos 3155, Peto 303 and H 9775, will field store two to three weeks. Though their yields are lower, the field-stored

yield will be higher than if planted later. In the EFS trials, yields have improved through the third harvest. After the third harvest is where the largest yield losses occur.

At first each grower and processor should work out their own schedule on a limited scale. A strong tomato root system is important for success of this program. Water should be cut off at least two weeks and on some soils up to 30 days before normal harvest. At the university field station 30 days cutoff or more before fruit is 90% ripe has worked best.

For more detailed information about EFS or “heat set” varieties, contact me at the UC West Side Research and Extension Center in Five Points.



SOURCES OF INFORMATION – Processing Tomatoes

PUBLICATIONS FROM UC

Many items are available at no cost from local UCCE offices or the World Wide Web.

Processing Tomato Production in CA, #7228

Mechanized Growing & Harvest of Processing Tomatoes, #2686 (currently out of print)

IPM Tomato Manual, #3274

IPM Tomato Pest Management Guidelines

Identification & Management of Complex Tomato Diseases (available through UC VRIC)

Scheduling Irrigation: When & How Much, #3396

UC Vegetable Research & Information Center
(UC VRIC) www.vric.ucdavis.edu

UC IPM (homepage)
www.ipm.ucdavis.edu

UC IPM (tomato section): www.ipm.ucdavis.edu/PMG/selectnewpest.tomatoes.html

UC Ag Economics: Cost of Production Guidelines
<http://coststudies.ucdavis.edu> or (530) 752-1515

UC Ag & Natural Resources Catalogue
<http://anrcatalog.ucdavis.edu>

INDUSTRY ORGANIZATIONS

CA Tomato Research Institute

www.tomatonet.org/ctri.htm

A voluntary assessment by growers to support research for processing tomato crop improvement.

CA Tomato Growers Association

www.ctga.org

Represents growers in the bargaining, economic, public policy and business leadership arenas.

CA League of Food Processors

www.clfp.com

Represents and promotes processors in CA.

Processed Tomato Foundation www.tomatonet.org/ptf

Partnership of CA tomato growers & processors to address food safety and environmental issues.

Processing Tomato Advisory Board

www.ptab.org

Established CA fruit quality standards and conducts grading program to assure high fruit quality.

WEATHER & IRRIGATION

CIMIS - CA Irrigation Management & Info System
CA Dept Water Resources - www.cimis.water.ca.gov
UC IPM - Weather, day degree modeling and CIMIS
www.ipm.ucdavis.edu/WEATHER/weather1.html

GOVERNMENT

CDFA - www.cdffa.ca.gov
CDPR - www.cdpr.ca.gov
CA AG Statistics Services - <http://www.nass.usda.gov/ca>
Curly Top Virus Control Program - (559) 445-5472

CALIFORNIA TOMATO PROCESSORS

Authentic Specialty Foods, Inc., Rosemead
CA Tomato Products, Colusa
Campbell Soup Company, Sacramento
Colusa County Canning Co., Williams
Con-Agra Grocery Products Co. (Hunt's),
Oakdale and Helm
Del Monte Corporation, Hanford
Escalon Premier Brands, Inc., Escalon
H. J. Heinz Company, Stockton
Ingomar Packing Co., Los Banos
Los Gatos Tomato Products, Huron
Morning Star Packing Co., Los Banos,
Riverbank, Volta, and Williams
Pacific Coast Producers, Woodland
Patterson Frozen Foods, Patterson
Pictsweet Frozen Foods, Inc., Santa Maria
Rio Bravo Tomato Co. LLC, Buttonwillow

San Benito Foods, Hollister
SK Foods, Inc., Lemoore
Stanislaus Food Products Co., Modesto
Toma Tek, Firebaugh
Uni Lever Best Foods, Stockton & Merced

Driers/Dehydrators

Borello Farms, Inc., Morgan Hill
Culinary Farms, West Sacramento
Gilroy Foods, Hanford
John Potter Specialty Foods, Inc., Patterson
Lester Farms, Winters
Mariani Nut Company, Winters
Timber Crest Farms, Healdsburg
Traina Dried Fruit, Patterson
Valley Sundried Products, Inc., Newman

**Special Edition of Vegetable Notes:
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South San Joaquin Valley***

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