



# PROCESSING TOMATO PRODUCTION IN CALIFORNIA

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## PRODUCTION AREAS AND SEASONS

Processing tomatoes (*Lycopersicon esculentum* Mill.) are grown in the San Joaquin and Sacramento Valleys, with production centered in Fresno, Yolo, San Joaquin, Kings, and Colusa Counties. Significant production also occurs in Merced, Stanislaus, Solano, and Sutter Counties. Fields are planted from late January through early June for continuous harvest from late June into October. California accounts for over 90 percent of U.S. production and approximately 35 percent of world production.

## PROCESSING TOMATO ACREAGE, YIELD, AND VALUE

Year	Acreage	Average yield per acre
2004	281,000	41.5
2005	267,000	36.4
2006	283,000	35.8

Source: USDA National Agricultural Statistics Service, <http://www.nass.usda.gov>.

## CLIMATIC REQUIREMENTS

Tomato is a warm-season crop that is sensitive to frost at any growth stage. The optimal soil temperature for seed germination is 68°F (20°C) or above; germination below 60°F (16°C) is extremely slow. Daily maximum air temperature between 77°F and 95°F (25° to 35°C) is ideal for vegetative growth, fruit set, and development. With adequate soil moisture, tomato plants can tolerate temperatures well in excess of 100°F (38°C), although fruit set can be adversely affected. Fruit development and quality are severely reduced when day and night temperatures fall below 68° and 50°F (20° and 10°C), respectively.

## VARIETIES AND PLANTING TECHNIQUES

Processors conduct extensive evaluations to identify varieties with appropriate characteristics for specific end products. Production contracts require growers to select from a list of approved varieties chosen by the processor. Growers select varieties from this list based on yield potential, earliness, and nematode and disease resistance. Hybrid varieties are now planted in nearly all fields. Dozens of varieties are commercially grown in California. The five most commonly grown varieties in 2005 were AB 2, Heinz 9780, Heinz 9557, Halley 3155, and Hypeel 303; these varieties constituted more than 60 percent of California production.

Since 1990 the trend has been from direct seeding to transplanting; the majority of tomato fields are now transplanted. Transplanting simplifies seedbed preparation and stand establishment, reduces weed competition, provides more options for weed control, and reduces hand-weeding expense.

To accommodate wet soil conditions in the spring, beds are generally made in the fall, allowing for timely planting and reduced soil compaction. Ground preparation prior to listing beds includes subsoiling, disking, and landplaning. Growers are increasingly experimenting with various approaches to reduce tillage, driven by the desire to reduce tillage costs and improve profitability. These alternative approaches vary from simply combining multiple operations into one equipment pass to minimum tillage schemes in which some operations are eliminated. Winter-grown cereal or legume cover crops preceding processing tomatoes can improve soil tilth and provide a “rotation” for fields in which tomato is planted in successive years. Despite these potential advantages, cover cropping remains an uncommon practice due to the



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costs involved and the difficulty of incorporating cover crop residue in wet spring weather.

In the San Joaquin Valley 66-inch (1.7-m) beds are common, while in the Sacramento Valley 60-inch (1.5-m) beds are the norm; beds are planted with either a single or double row of plants. Seeding rates are usually 40,000 to 60,000 seeds per acre (100,000 to 150,000 per ha), with a desired final plant spacing of 2 to 3 plants per clump 9 to 12 inches (22.5 to 30 cm) apart in the seed line. Mechanical and precision vacuum planters are used to meter seed. Tomatoes can compensate for thin stands, with gaps up to 30 inches (75 cm) between plants causing only minor yield loss. Seeding depth varies from 0.5 inch to over 1.5 inches (1.2 to 3.7 cm), depending on soil characteristics. Seedling emergence may require more than 30 days under cool soil temperatures. Under soil temperatures in the 80°F (27°C) range, emergence occurs within 7 days of planting.

Transplants are custom-grown by commercial greenhouse operations and are delivered to the field as plug plants seeded in trays. Transplants are mechanically planted into fields starting in early March and continuing until early June. Both mechanical finger type, hand-fed transplanters and carousel, rotary transplanters are commonly used. Automated systems are being evaluated. Transplant populations of single- or double- seeded plugs are typically 7,000 to 9,000 per acre (17,300 to 22,200 per ha). Water, usually containing N and P fertilizer, is often applied at transplanting at rates up to 400 gallons per acre (3,745 l/ha). Alternatively, a pre-transplanting fertilizer application to the soil is also common.

Mechanical cultivation operations help control weeds, minimize large clods on the bed surface, and maintain deep furrows and a smooth, slightly crowned bed surface to facilitate mechanical harvest. A mechanical vine trainer is often needed to push vines out of the furrow onto the bed, or a mechanical cutter is used to trim excessive vine growth. Maintaining an unobstructed furrow increases furrow irrigation efficiency and provides better fruit recovery at harvest.

## SOILS

A variety of soil textures are used for processing tomato production. Sandy soils are preferred for early planting because they can be planted sooner during wet weather and warm more rapidly in the spring, promoting seed germination and early growth. Loam and clay loam soils are generally more productive than sand. Clay soil may be used, provided it is well-drained and irrigated carefully; *Phytophthora* root rot, a soilborne fungal disease, can be a serious problem in heavy soils with excessive soil moisture.

## IRRIGATION

All processing tomatoes are irrigated. Sprinkler irrigation is used primarily for stand establishment, although a few growers use sprinklers throughout the growing season. Furrow irrigation is the most common irrigation technique employed after stand establishment. Irrigation frequency varies widely by grower, soil type, and growth stage; 7- to 14-day intervals are typical. It is a common practice to cut off irrigation 2 to 4 weeks before harvest to enhance the soluble solids content of the fruit, reduce the risk of fruit rots, and minimize soil compaction from mechanical harvest operations.

The use of drip irrigation is increasing substantially each year; currently more than 20 percent of processing tomato acreage is under drip management. Drip irrigation generally increases yield and allows efficient irrigation of fields that, because of slope or soil characteristics, are difficult to irrigate by other means. Also, in a large area of the San Joaquin Valley the presence of a shallow, saline water table complicates irrigation management. The use of drip irrigation in this area maintains productivity by keeping the root zone relatively salt-free, and the high efficiency of drip irrigation minimizes the volume of drainage water generated. The typical drip system employs a single drip tape buried 8 to 12 inches (20 to 30 cm) deep in the bed center, although the use of surface drip systems (in which the drip lines are laid in the furrows after crop establishment) is becoming increasingly common. Sprinkler irrigation is often used for transplant or seedling establishment, with drip irrigation beginning around first bloom. Drip irrigation requirements are determined by weather-based reference evapotranspiration (ET<sub>0</sub>) estimates and crop growth stage; irrigation frequency may vary from once or twice a week early in the season to daily irrigation during periods of peak water demand. Some growers reduce irrigation in the final 4 to 6 weeks of the season to increase fruit soluble solids concentration.

## FERTILIZATION

Fertilizer application rates vary widely among California tomato growers. Typical seasonal application rates are 125 to 250 pounds of nitrogen (N) per acre (140 to 280 kg N/ha), 40 to 120 pounds of P<sub>2</sub>O<sub>5</sub> per acre (20 to 60 kg P/ha), and 0 to 200 pounds of K<sub>2</sub>O per acre (0 to 185 kg K/ha). University of California research has shown that under normal conditions, maximum yield can be obtained with approximately 100 to 150 pounds of N per acre (112 to 168 kg/ha), and even less in fields with substantial residual soil nitrate from prior cropping. Soils with bicarbonate-extractable phosphorous (P) greater than 20 ppm are unlikely to respond to P application, although a

temporary early growth response to preplant P may be seen in early spring conditions. Below 15 ppm, a yield response to applied P would be expected. Many California soils have adequate potassium (K) for high-yield tomato production. However, on soil with ammonium acetate-exchangeable K less than 150 ppm, K application may be required; seasonal K rates seldom exceed 200 pounds of K<sub>2</sub>O per acre (185 kg K/ha). Fruit color uniformity is an important quality factor for peel/dice processing. A common disorder called yellow shoulder, in which the tissue surrounding the stem scar remains yellow after fruit ripening, is encouraged by K deficiency. Although K fertilization in excess of that required to maximize yield may reduce the incidence of yellow shoulder, such applications are usually not economical.

Micronutrients are seldom deficient in the mineral soils of the San Joaquin and Sacramento Valleys. Zinc deficiency does occur and is normally corrected by including zinc with the preplant macronutrient fertilizer. Gypsum is commonly applied as a soil conditioner to improve soil structure and water infiltration but seldom for its nutrient value since most California soils have sufficient calcium and sulfur to meet plant requirements.

Regardless of irrigation method, most P is applied preplant or at transplanting. Where drip irrigation is used, most N and K (if needed) are applied by fertigation throughout the season. In conventionally irrigated fields, N and K (if needed) are applied preplant or at planting, and in one or more sidedressings; late-season water-run application may also occur.

## INTEGRATED PEST MANAGEMENT

Detailed information on integrated pest management (IPM) for tomato production is available in the UC IPM Pest Management Guidelines for Tomato, <http://www.ipm.ucdavis.edu/PMG/selectnewpest.tomatoes.html>. and in ANR Publication 3274, *Integrated Pest Management for Tomatoes, 4th edition*. Cultural control methods such as mechanical cultivation, field sanitation, good drainage, and irrigation management to avoid excessively wet soils are important components of IPM that help minimize the need for chemical controls. Monitoring for and correctly identifying pests are also key components of an effective IPM program. Pesticides should always be used in compliance with label instructions.

### Weed Management

Control of annual and perennial weeds is important for maximum crop production and harvest efficiency. Hand-weeding can be a major expense in direct-seeded fields if weeds are prevalent. Late-winter and early-spring weeds can be controlled chemically or by cultivation prior to planting. In direct-seeded fields

herbicides are often applied postemergence to seedling tomatoes. Use of a preplant herbicide incorporated with a rotary tiller prior to transplanting is common. In fields with a history of nightshade (*Solanum nigrum* and *S. sarrachoides*) infestation, a fumigant can be banded along the seed line with a subsurface spray blade prior to planting. Postemergent herbicide sprays to control nightshades are also widely used. Cultivation along the seed line precedes hand-thinning and weeding in the seed line; no hand-weeding is necessary in transplanted fields at this stage. Lay-by herbicide application is the norm to control weeds for the remainder of the season, regardless of planting method. Additional hand-weeding may be required to prevent escaped weeds from producing seed. Crop rotation can reduce weed pressure.

### Insect Management

The primary arthropod pests of tomato seedlings are garden symphylans (*Scutigera immaculate*), flea beetles (*Epitrix* spp.), and cutworms (*Peridroma* and *Agrotis* spp.). General foliage and fruit feeders are tomato fruitworms (*Helicoverpa zea*), various armyworms (*Spodoptera* spp.), russet mites (*Aculops lycopersici*), stink bugs (*Euschistus conspersus*, *Thyanta pallidovirens*, *Chlorochroa* spp., and *Nezara viridula*), and potato aphids (*Macrosiphum euphorbiae*). Pinworms (*Keiferia lycopersicella*) are an occasional problem in the southern San Joaquin Valley. Various insecticides are used for control. A UC IPM monitoring program is available for determining treatment thresholds for fruitworm, armyworm, potato aphid, and consperse stink bug control programs.

### Nematode and Disease Management

Root knot nematodes (*Meloidogyne* spp.) have been controlled under most circumstances by crop rotation and use of resistant varieties. Phytophthora root rot (*Phytophthora parasitica* and *P. capsici*) is a concern throughout the season. Careful irrigation management to avoid saturating soils for extended periods is the most useful control practice.

The Mediterranean weather conditions of California's Central Valley limit disease problems. In cool, rainy springs bacterial speck (*Pseudomonas syringae*) and bacterial spot (*Xanthomonas campestris*) can be problematic. Copper sprays are commonly used. Bacterial speck-resistant varieties are widely grown, but a new strain of the bacterium has recently appeared that can cause disease even on resistant varieties. Late blight (*Phytophthora infestans*) is a concern, occurring in the late spring during rainy periods and in the fall when wet weather returns. Protectant chemicals may be used for control. In late-season fields protectant fungicides are often applied to minimize fruit damage from blackmold (*Alternaria alternata*).



*Fusarium* wilt (*Fusarium oxysporum*) race 2 occurs primarily in the Sacramento and northern San Joaquin Valleys; race 3 is generally limited to the Sutter Basin and Yolo County. *Verticillium* wilt (*Verticillium dahliae*) race 2 is widespread but losses have not been devastating. Corky root (*Pyrenochaeta lycopersici*) is common throughout the Central Valley. The primary control strategies of extending crop rotations and delaying planting in fields with corky root history until soil is warm are only partially effective. *Fusarium* root rot (*Fusarium solani*) is becoming more prevalent.

### Other Pests and Problems

A number of viruses can affect processing tomatoes, including curly top, spotted wilt, and alfalfa mosaic. The severity of loss to virus diseases varies from year to year depending on factors such as weather, populations of insect vectors (aphids, thrips, and leaf hoppers primarily), and the presence of host plants in the landscape. Significant economic losses may be seen in individual fields or regions (particularly with curly top and tomato spotted wilt), but in general widespread losses are uncommon in California. The whitefly-transmitted gemini virus tomato yellow leaf curl (TYLCV) has recently been identified in tomato fields in the Imperial Valley, but to date it has not been found in the San Joaquin Valley.

### HARVESTING AND HANDLING

All California processing tomatoes are mechanically harvested. The once-over, destructive harvest is initiated when at least 90 percent of fruit are ripe. In some fields a fruit ripening agent is applied several weeks before harvest to maximize the percentage of ripe fruit and to promote earlier harvest. Some growers own or lease self-propelled harvesters, although contract harvesting by processors is common. Fruit are loaded

into tandem bulk trailers each holding approximately 12 tons and transported to a processing plant.

### POSTHARVEST HANDLING

All bulk loads are graded at one of the fruit inspection stations located throughout the production areas. The Processing Tomato Advisory Board administers this statewide program. Fruit color, soluble solids content, pH, and defect levels (insect damage, mold, green fruit, etc.) are evaluated. Tomatoes are then processed into a wide variety of products. Some processing plants directly manufacture finished consumer products, while others specialize in the production of bulk paste or whole-peeled or diced fruit. These bulk items are subsequently remanufactured into sauces, catsup, and so on. Several small-scale processors produce dried tomato products.

### MARKETING

Processing tomatoes are grown under contract to specific processors. Growers are paid a contracted price based on tonnage, quality, and date of delivery. Some contracts also contain incentives for achieving high fruit quality, particularly for soluble solids concentration. Processor requirements vary depending on the desired end product. Some processors exclusively produce products under their own proprietary labels, while others specialize in producing bulk items for remanufacture by other companies. Copacking agreements, in which one processor manufactures products under specific guidelines for another processor, are common. The production of organic processed tomato products is increasing, although organics still constitute a very small segment (less than 3%) of the overall industry.

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