PUBLICATION **8017**

Fresh-Market Tomato Production in California

MICHELLE LE STRANGE, University of California Cooperative Extension Farm Advisor, Tulare and Kings Counties; **WAYNE L. SCHRADER,** UCCE Farm Advisor, San Diego County; **TIMOTHY K. HARTZ,** Extension Vegetable Specialist, UC Davis

UNIVERSITY OF CALIFORNIA
Division of Agriculture and Natural Resources
http://anrcatalog.ucdavis.edu

VEGETABLE RESEARCH AND INFORMATION CENTER
Vegetable Production Series

PRODUCTION AREAS AND SEASONS

Fresh-market tomatoes (*Lycopersicon esculentum*) are grown in most counties in California, but 90 percent of the acreage is grown in nine counties. In 1999 the largest fresh-market tomato producing counties were San Joaquin (11,130 acres), Merced (9,014 acres), Fresno (6,500 acres), San Diego (4,258 acres), Kern (2,340 acres), Stanislaus (1,630 acres), Kings (1,394 acres), Tulare (1,369 acres), and Sacramento (1,052). In the Central Valley, fields are planted from March through July for harvest from June through October. In Southern California coastal counties, spring production fields are planted from mid-January to mid-March for harvest from May through July, and fall production fields are planted from June to early August for harvest from September through January. Table 1 shows the fresh-market tomato acreage and value in California for the past three years.

Table 1. Fresh-market tomato acreage and value

Year	Acreage	Average yield (tons/acre)	Gross value/ acre ($)
1999	44,000	12.5	5,500
1998	41,000	12.0	7,944
1997	40,800	14.2	7,695

Source: California Agricultural Resource Directory 2000 (Sacramento: California Department of Food and Agriculture).

CLIMATIC REQUIREMENTS

The tomato is a warm-season vegetable crop that is sensitive to frost at any stage of growth. The optimum soil temperature for seed germination is 68°F (20°C) or above; seed germination below 60°F (16°C) is very slow. Optimal production temperatures are between 70° and 80°F (21° and 27°C). These temperatures are ideal for vegetative growth, fruit set, and development. With adequate soil moisture, tomato plants can tolerate temperatures in excess of 100°F (38°C), although fruit set is adversely affected. Tomato fruit development and quality are reduced when day temperatures fall below 68°F (20°C), and plants undergo chilling injury when night temperatures fall below 50°F (10°C).

VARIETIES AND PRODUCTION METHODS

Two distinct growing methods are used in California. Some fresh-market tomatoes are grown on poles (stakes), harvested at the pink fruit stage in several picks, and marketed as vine-ripe. Most fresh-market tomatoes are grown as bushes without support and are harvested with one or sometimes two picks at the mature green fruit stage. Specialty tomatoes destined for niche markets, such as cherry, heirloom, cluster, and hothouse, require specific cultural practices that are not discussed in this publication.

Pole Production of Fresh-Market Tomatoes

Fresh-market tomatoes have traditionally been grown on poles in Southern Californian coastal counties. This practice greatly increases total production costs but decreases unit costs. This is due to an extended harvest and increased yields. Tomatoes are normally grown under plastic row covers for temperature control when planted in January or February. Half tents are used to protect plantings made in mid-March. Open plantings are possible from April through August in Southern California, but market prices generally restrict production to spring and fall periods.

Tomato transplants are planted on single row, drip-irrigated, 60- to 72-inch (152- to 183-cm) beds with 18- to 20-inch (46- to 51-cm) in-row spacing. Stakes are placed between every two or three plants. An apical wire is stapled to the stakes and anchored at row ends. Plants are pruned to one shoot below the first flower cluster and tied up with horizontal figure-eight wraps of twine between stakes. Plants are tied four to six times during the season at approximately 1-foot intervals as plants grow up the supporting lattice. In order to increase pollination and fruit set, tying is done in the dry time of the day for added vibration of flowers when pollen is less sticky. It takes from 80 to 110 days from transplanting to first harvest in pole tomato production, depending on the growing season. Harvesting may last for 70 to 120 days, or longer, depending on the market, disease, insect, and climatic conditions. Bingo, Merced, Tango, and Celebrity are among the varieties grown for pole production. Tomato varieties differ in fruit characteristics, disease resistance, and climatic adaptability. These factors should be carefully considered when selecting varieties for production.

Bush Production of Fresh-Market Tomatoes

In the Central Valley fresh-market tomatoes are transplanted. Determinate, bush-type, hybrid varieties account for 100 percent of the acreage. The commonly planted round-fruited varieties are Shady Lady, Sunbrite, QualiT 21, Merced, and Sonnet. A few Roma varieties are also used in fresh-market production, but acreage is relatively small. Hybrid 882, Yaqui, and Monica are the most common Roma varieties. Varieties are bred and selected for desirable fruit characteristics such as size, shape, firmness, smoothness, small blossom scars, nematode and disease resistance, and performance under various climatic conditions.

Transplants are preferred because of costly hybrid seed, earliness, and weed control. Transplants are grown by commercial greenhouses from seed that the grower supplies. A tractor-pulled, 3-row transplanter is used to transplant a single line on 60- to 66-inch (152- to 168-cm) raised beds at a 17- to 18-inch (43- to 46-cm) spacing between plants. Final plant stands are approximately 5,300–5,800 plants per acre (13,100–14,300 plants/ha).

Occasionally an early fresh-market tomato crop is transplanted into the field before the danger of frost is over and is protected from frost with hotcaps, plastic tunnels, or mulches. To accommodate wet soil conditions in the spring, beds are prepared in the fall, allowing for timely planting and reduced soil compaction. Where furrow irrigation is used, ground preparation prior to listing beds includes sub-soiling, disking, and land planing. Proper field leveling is critical for good drainage and for reducing disease incidence. Cultivation operations during the season maintain deep furrows and a smooth, slightly crowned, bed surface. Where permanent subsurface drip irrigation is used, beds are cultivated and disked with modified equipment that avoids damaging the buried tubing.

SOILS

A wide variety of soil textures are used for fresh-market tomato production. Sandy soils are preferred for early plantings. This is because planting can be done in sandy soils more easily during wet weather. Sand also warms more rapidly in the spring, promoting early growth. Loam and clay loam soils, however, are generally more productive than sand. Clay soil may be used, provided it is well drained and irrigated with care. Phytophthora root rot, a soilborne fungal disease, can be a serious problem in heavy soils when over-irrigation or poor soil drainage results in excess soil moisture for extended periods of time.

IRRIGATION

All fresh-market tomatoes are irrigated. Surface drip irrigation is used primarily in pole production. In bush production approximately one-third of the acreage is grown using subsurface drip irrigation (drip tape buried 2 to 12 inches [5–30 cm] deep, one line per bed), and two-thirds of the acreage utilizes furrow irrigation. The amount of drip irrigation applied is generally calculated by considering crop growth stage and using reference evapotranspiration (ETo) data available from the California Irrigation Management Information System (CIMIS). Drip-irrigated fields are kept near field capacity throughout the season. Soil moisture is monitored with sensing devices, such as tensiometers. Frequency of irrigation may vary from once or twice a week to daily, depending upon season, climate, soil type, and plant growth stage. Throughout the season, an average of 20 to 24 and 30 to 36 acre-inches (2,060 to 2,470 m^3 and 3,090 to 3,710 m^3) of water are applied to bush- and pole-grown tomatoes, respectively. Drip irrigation improves irrigation efficiency and allows hand harvesting at regular intervals. Subsurface drip irrigation has the added benefit of a dry bed surface and reduced weed germination.

Sometimes sprinkler irrigation is used to establish the young transplants in bush production before switching to buried drip or furrow irrigation. Continued use of sprinklers favors bacterial leaf spotting diseases such as bacterial speck (*Pseudomonas syringae*) and bacterial spot (*Xanthomonas campestris*), fruit diseases such as early blight (*Alternaria solani*) and late blight (*Phytophthora infestans*), and molds (*Pythium, Alternaria,* and *Sclerotinia* spp.). Furrow irrigation frequency varies widely by grower, soil type, and crop growth stage; 7- to 14-day intervals are common. Tomatoes have a relatively deep root system and thrive on deep infrequent irrigation. Watering less frequently reduces root-rot diseases and favors weed control. As bushes become loaded with fruit, irrigation may become more frequent, however it is extremely important to keep bed tops dry to minimize fruit rot and decay organisms. An average of 2½ to 3 acre-feet (3,080 to 3,700 m^3) of water are applied throughout the season on furrow-irrigated fields.

FERTILIZATION

Fertilizer application rates vary widely among California tomato growers. Typical seasonal application rates are 125 to 250 pounds per acre (140–280 kg/ha) of nitrogen (N) for bush-grown tomatoes and 150 to 350 pounds per acre (168–392 kg/ha) of nitrogen for pole-grown tomatoes. University of California research has shown that under normal conditions, maximum yield in either bush or pole-grown tomatoes can be obtained with approximately 100 to 180 pounds per acre (112–202 kg/ha) of nitrogen up until the first harvest. For pole tomatoes with an elongated harvest season, maintenance applications of up to 10 pounds per acre (11 kg/ha) of nitrogen per week may be necessary.

Phosphorus (P) application rates of 60 to 120 pounds per acre (67–134 kg/ha) of P_2O_5 are adequate for the majority of tomato fields, but actual application rates often range from 80 to 160 pounds per acre (90–179 kg/ha). Residual soil phosphorus level, soil temperature, and soil pH should guide the grower's decisions. Soils with bicarbonate-extractable phosphorus greater than 15 parts per million (ppm) are unlikely to respond to phosphorus application under warm soil conditions. However, an early spring planting may show a growth response to preplant applications of phosphorus. Below 12 parts per million, a yield response to applied phosphorus would be expected.

Typical applications of potassium (K) range from 0 to 120 pounds per acre (0–134 kg/ha) of K_2O. California soils generally have adequate potassium for high-yield tomato production. However, on soils with ammonium-acetate–extractable potassium less than 150 ppm, additional potassium may be required; seasonal rates vary from 60 to 200 pounds per acre (67–224 kg/ha) of K_2O.

Regardless of irrigation technique, most phosphorus is applied preplant or at transplanting in a banded application. Where drip irrigation is used, nitrogen is applied in numerous, small fertigations throughout the season. In furrow-irrigated fields, nitrogen is applied preplant and in one or more sidedressings; late-season, water-run applications are also common. If potassium is needed, it is applied in a manner similar to that of nitrogen.

INTEGRATED PEST MANAGEMENT

Detailed information on integrated pest management (IPM) for tomato production is available in *IPM for Tomatoes* (UC DANR Publication 3274) and *UC IPM Pest Management Guidelines for Tomato* (DANR Publication 3339). Or, contact the UC IPM World Wide Web site at http://www.ipm.ucdavis.edu. Cultural controls such as mechanical cultivation, field sanitation, good drainage, and irrigation management are important components of integrated pest management that help minimize chemical controls. Pesticides should always be used in compliance with label instructions.

Weed Management

Control of annual, biennial, and perennial weeds is important for maximum crop production and harvest efficiency. Late-winter and early-spring weeds can be controlled chemically or by cultivation prior to planting. Use of a preplant herbicide incorporated with a power-driven rotary tiller prior to transplanting is common. Transplanting provides the crop with an initial growth and competitive advantage over weeds and reduces stand establishment problems. Subsequent cultivations further reduce weed populations. Within the crop row, soil is pushed toward the base of the plants to bury small weeds and create a dry mulch. Cultivation and lay-by herbicide applications are done as necessary to control weeds. Hand-weeding is common and can be a major expense, especially if weeds are abundant or particularly troublesome like nightshades (*Solanum* spp.), which are hard to distinguish from tomatoes and are tolerant to most herbicides labeled for use in tomato. Crop rotation can reduce weed pressure by utilizing cultivation techniques and herbicides registered for use in those crops to manage weed populations.

Insect and Mite Identification and Management

The primary insect pests of tomato seedlings are flea beetles (*Epitrix* spp.), darkling ground beetles (*Blapstinus* spp.), and cutworms (*Peridroma* and *Agrotis* spp.), but

these are not typically major problems in transplanted fields. Sometimes the garden symphylan (*Scutigerella immaculata*), also called the garden centipede, can damage young transplants in the field. General foliage and fruit feeders are tomato fruitworms (*Helicoverpa zea*), various armyworms (*Spodoptera* spp.), leafminers (*Liriomyza* spp.), russet mites (*Aculops lycopersici*), stink bugs (*Euschistus conspersus, Thyanta pallidoverins, Chlorochroa* spp., and *Nezara viridula*), thrips (several species), and potato aphids (*Macrosiphum euphorbiae*). Pinworms (*Keiferia lycopersicella*) are an occasional problem in the southern San Joaquin Valley and southern coastal counties. Various insecticides are used for control. A University of California IPM monitoring program is available for determining treatment thresholds for fruitworm and armyworm control programs.

Nematode and Disease Identification and 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 completely saturating soils for extended periods is the most useful control. Fusarium wilt (*Fusarium oxysporum*) race 2 occurs primarily in the Sacramento Valley. Verticillium wilt (*Verticillium dahliae*) race 2 is widespread but losses have not been devastating. Corky root (*Pyrenochaeta lycopersici*) is problematic in some areas, and the typical control strategy is to avoid early plantings when soil temperatures are cool.

Mediterranean weather conditions in California limit fungal and bacterial disease problems. In cool, rainy springs, bacterial speck (*Pseudomonas syringae*) and bacterial spot (*Xanthomonas campestris*) can be problematic. Copper sprays are normally used, and recently available speck-resistant varieties can be planted. Bacterial canker (*Clavibacter michiganensis* subsp. *michiganensis*) occurs sporadically; it is seedborne and spreads rapidly within a greenhouse. Planting clean transplants is the most important control measure. Late blight (*Phytophthora infestans*) is a concern in the greenhouse and in the field; it occurs in late spring during rainy periods and in fall wet weather conditions. Fruit-protectant chemicals, applied by ground application equipment for optimum coverage, may be used for control. On fall fields, protectant fungicides are applied to minimize damage from black mold (*Alternaria alternata*).

Several viruses affect tomatoes. Most common are curly top, cucumber mosaic, tobacco mosaic, tobacco etch, and potato Y. Tomato spotted wilt and tobacco streak are less common. Virus damage can cause negligible to substantial yield loss. Whitefly-transmitted gemini viruses affecting tomatoes have not yet been found in California; use of transplants grown outside of California is strongly discouraged.

Other Problems

Blossom end rot begins as a small, light brown spot that gradually expands into a sunken, leathery, brown or black lesion at the blossom end of the tomato. This is a physiological disorder resulting from low calcium uptake in fruit induced by inadequate irrigation during early fruit development. Foliar sprays of calcium nitrate reduce this malady in the greenhouse, but have generally not been effective in the field. Proper irrigation scheduling is the most effective control measure.

HARVESTING

Pole Production

Pole-grown, fresh-market tomatoes are harvested by hand into lug boxes when fruit are between the breaker and pink stages of color development (USDA #2 and #4). Harvesting is done frequently to avoid overripe fruit. Fruit is picked from one to three times per week, depending on weather and harvest period. Yields of 2,500 to 3,000 cartons (30–35 tons) per acre (68–79 t/ha) are average and yields of 4,000 cartons (45–50 tons) per acre (101–113 t/ha) have been achieved.

Fruit is transported to sheds where it is washed and graded for size and color and then place packed in two- or three-layer cardboard flats. Two-layer flats (4x4 to 6x6) contain 32 maximum large to 72 medium sized tomatoes and weigh about 18 pounds. Three layer flats (6x6 to 7x8) contain 108 medium to a maximum of 168 small fruit and weigh approximately 28 pounds (13 kg). Production costs for pole-grown, fresh-market tomatoes are approximately $16,400 per acre including pick, pack, and selling costs (break-even cost is approximately $5.45 per carton).

Bush Production

Bush-grown, fresh-market tomatoes are hand-harvested when 10 to 15 percent of the fruit is red (approximately 80 to 110 days after transplanting). The minimum harvest maturity level is a mature green 2 (MG2), which is defined by internal fruit structures: seeds are fully developed and are not cut upon slicing the fruit, gel formation is advanced in at least one locule, and jelly-like material is forming in other locules. Mature green, breaker, and pink stages are picked into buckets then dumped into bins or gondolas for transport from the field to the packing shed. Bush-grown, fresh-market tomatoes are rarely picked more than one time during the harvest season.

At the shed, tomatoes are rinsed, sorted by size and grade, and the majority are bulk-packed into 25-pound (11-kg) cartons. Premium fruit is hand-packed into one- and two-layer cartons as described above under **Pole Production**. Standard tomato quality is primarily based on uniform shape and freedom from defects. Cartons of fruit are typically stored in a temperature-controlled chamber for 1 to 10 days and subjected to an ethylene treatment prior to shipment to market.

Gross yields range from 12 to 25 tons per acre (27–56 t/ha) in the San Joaquin Valley. The average pack-out rate ranges from 60 to 75 percent, netting 8 to 18 tons (640–1,400 cartons) per acre (18–41 t/ha) of marketable fruit. The total cost of harvest and packing is approximately $3.75 per carton, and the total cash costs/carton ranges between $4.75 and $5.75.

POSTHARVEST HANDLING

Rapid cooling soon after harvest is recommended to optimize postharvest quality of the tomato. Vine-ripened fresh-market tomatoes are cooled by forced air and should be stored in cool rooms at no lower than 50°F (10°C) to extend shelf-life. Mature-green fruit can be ripened right away, ripened slowly, or stored before going through the ripening process. Normal ripening temperatures are 65° to 70°F (18° to 21°C), while slow ripening temperatures are 57° to 61°F (14° to 16°C). Mature-green tomatoes can be stored for 2 weeks at 55°F (13°C) before ripening without a significant

decline in ripening rate, color development, or sensory (eating) quality. Longer storage at this chill injury threshold will accelerate decay, and tomatoes will fail to develop deep red color. Mature-green tomatoes are normally treated with 100 to 150 ppm of ethylene for 24 to 48 hours at 68° to 77°F (20° to 25°C) before shipment to assure uniform ripening. Repacking may be required if color development is not uniform. (For additional information on postharvest handling of tomatoes, refer to "Produce Facts—Tomato" in Perishables Handling Newsletter #90, May 1997, available from the University of California, Davis, Postharvest Outreach Program or at http://postharvest.ucdavis.edu).

MARKETING

Tomatoes are available year-round in the United States. Although most states grow tomatoes to some extent, California produces nearly 30 percent of the nation's supply of fresh-market tomatoes and ranks second behind Florida in total production. Mexico is the third largest supplier of tomatoes to the United States. While Florida and California mainly produce mature-green tomatoes, the role of vine-ripened tomatoes has been increasing. The majority of tomatoes imported from Mexico are extended shelf-life (ESL) vine-ripened tomatoes.

In California tomatoes are grown and marketed by vertically integrated companies (grower-packer-shipper) and are distributed throughout the United States. California tomatoes are available from May to December with supplies peaking in July and again in September and October. Fresh-market tomatoes are sold via retail and food service marketing channels. Approximately 60 percent of mature-green tomatoes are marketed in states west of the Mississippi, 25 percent are sold east of the Mississippi, and 15 percent are exported to Canada, Japan, and Mexico. Vine-ripened tomatoes are more widespread in retail markets throughout the United States. They are also more often sold directly to retail stores and food service handlers as originally packed, whereas mature-green tomatoes are usually repacked in the food distribution chain before they are sold to these markets. Prices to growers are primarily based on supply and demand, although there is some contract pricing for tonnage by large commercial chain stores.

FOR MORE INFORMATION

You'll find detailed information on many aspects of tomato production in these UC ANR publications:

Integrated Pest Management for Tomatoes, Fourth Edition, publication 3274
Commercial Cooling of Fruits, Vegetables, and Flowers, publication 21567
Commercial Greenhouse Vegetable Handbook, publication 21575

To order these materials, visit our online catalog at http://anrcatalog.ucdavis.edu. You can also place orders by mail, phone, or fax, or request a printed catalog of publications, multimedia, slide sets, and videos from

University of California
Division of Agriculture and Natural Resources
Communication Services
6701 San Pablo Avenue, 2nd Floor
Oakland, California 94608-1239

Telephone: 1-800-994-8849 or (510) 642-2431, FAX: (510) 643-5470
e-mail inquiries: danrcs@ucdavis.edu

An electronic version of this publication is available on the ANR Communication Services website at http://anrcatalog.ucdavis.edu.

Publication 8017

pr-11/00-GM/WJC ISBN 978-1-60107-197-2