PRODUCTION AREAS AND SEASONS

California has four main bell pepper (*Capsicum annuum* L.) production areas: the southern desert valleys (Imperial and Riverside Counties), the southern coast (San Diego, Orange, and Ventura Counties), the central coast (San Luis Obispo, Monterey, San Benito, and Santa Clara Counties), and the Central Valley (Kern, Tulare, Fresno, Merced, Stanislaus, Sacramento, and San Joaquin Counties).

Nearly all fields in the southern desert valleys are transplanted in January or February for harvest from late April through June. On the southern coast, planting also begins in January and continues through May for harvest from May through September. In the central coast, planting is done from March to June for harvest from August to November. Planting in the Central Valley begins in Kern County in February and proceeds northward over the next four months for harvest from late May to November.

BELL PEPPER ACREAGE AND VALUE

<table>
<thead>
<tr>
<th>Year</th>
<th>Acreage</th>
<th>Average yield (tons/acre)</th>
<th>Gross value/acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>1994</td>
<td>19,000</td>
<td>15.0</td>
<td>$7,640</td>
</tr>
<tr>
<td>1993</td>
<td>18,500</td>
<td>15.0</td>
<td>$8,060</td>
</tr>
<tr>
<td>1992</td>
<td>20,000</td>
<td>14.3</td>
<td>$5,220</td>
</tr>
</tbody>
</table>

Source: Annual California County Agricultural Commissioners' Report Data (Sacramento: California Department of Food and Agriculture, 1992–1995).

CLIMATIC REQUIREMENTS

Bell pepper is a warm-season crop, sensitive to freezing temperatures at any growth stage. Rate of seed germination decreases rapidly below 77°F (25°C), with germination below 68°F (20°C) exceedingly slow. Day temperatures of 75°F to 85°F (24° to 30°C) with night temperatures about 15°F to 20°F (9° to 12°C) lower are ideal for growth. Although tolerant of temperatures above 100°F (38°C), such extreme conditions can reduce effective pollination, fruit set, and yield.

VARIETIES AND PLANTING TECHNIQUES

Most bell peppers grown in California are open-pollinated varieties, with Jupiter, Capistrano, Grande Rio 66, Yolo Wonder, California Wonder 300, and Keystone Resistant Giant strains accounting for most of the acreage. Hybrid varieties in use include Indra, Bell Star, Excalibur, Galaxy, and King Arthur.

Nearly all fields in the southern desert valleys and coastal regions are transplanted, as are most fields in the southern half of the Central Valley. Elsewhere, both transplanting and direct seeding are common. Due to very high seed cost, all hybrid varieties are transplanted. Small acreages of specialty “colored” peppers (mature fruit color other than red) are grown in all regions.

In the southern desert valleys and coastal areas, peppers are usually grown in double rows on raised beds, 60 to 72 inches (1.5–1.8 m) wide, with plastic mulch and drip irrigation. Much of the acreage is fumigated before transplanting. These practices maximize earliness and yield, and in the coastal areas, help compensate for the high cost of land and water. Elsewhere in the state, neither fumigation nor plastic mulching is common, and a wide variety of field configurations is used. Bed width varies from 30 to 66 inches (0.75–1.65 m), with one or two rows of plants per bed; in-row plant spacing ranges from 8 to 16 inches (20–40 cm). Where direct seeding is done, 0.5 to 2 pounds of seed per acre (0.6–2.2 kg/ha) is used. Higher rates are used early in the season when soil temperature is suboptimal; pepper seed germinates slowly and erratically below 68°F (20°C).

SOILS

Many soil textures are used for bell pepper production. Sandy soils are preferred for the earliest plantings because they warm more rapidly in the spring. Heavier soils can be quite productive, provided they are well drained and irrigated with care. *Phytophthora* root rot, a soilborne fungal disease, can be a serious problem in soils that receive excessive irrigation or rainfall.
IRRIGATION

Statewide, at least 30 percent of bell pepper acreage is drip-irrigated, and the use of drip is increasing rapidly. Most drip systems employ lines buried 2 to 10 inches (5–25 cm) deep, with either one or two drip lines per bed. The irrigation requirement is determined by weather-based reference evapotranspiration (ET₀) estimates and crop growth stage; the frequency of irrigation can vary from once or twice a week early in the season to daily during times of peak water demand.

The remainder of California pepper acreage is predominately furrow-irrigated. Sprinkler irrigation is sometimes employed for seedling establishment and early-season watering but is seldom used for the entire production season. The frequency of furrow or sprinkler irrigation varies widely, depending on soil type, environmental conditions, and crop growth stage. Although peppers are moderately deep-rooted, they are quite sensitive to moisture stress. Stress during bloom can cause substantial reduction in fruit set, while stress during early fruit growth can induce blossom end rot. Soil moisture stress can also minimize foliage cover, increasing sunburning of fruit.

FERTILIZATION

Bell pepper is among the most heavily fertilized crops grown in California. Preplant phosphorus (P) application of 80 to 200 pounds per acre (90–224 kg/ha) of P₂O₅ is common; the higher rates generally are used on early-spring plantings or in alkaline soils. Many California soils have adequate potassium (K), but in some areas K deficiency may be encountered. Soils with ammonium acetate extractable K less than 120 ppm should be fertilized with K; appropriate seasonal rates vary from 50 to 150 pounds per acre (56–168 kg/ha) of K₂O, depending on soil test value.

Regardless of irrigation technique, most P is applied preplant, usually in a banded application. Where drip irrigation is used, nitrogen (N) and K are usually applied in numerous small fertigations throughout the season. In conventionally irrigated fields, N and K are applied preplant and in one or more sidedressings; late season water-run application is also common.

Nitrogen fertilization rates tend to be very high, with many growers using more than 300 pounds per acre (336 kg/ha) seasonally. It is a widespread belief that very high N rates increase plant vigor, foliage cover, and fruit size, which in turn increases yield and decreases sunburn damage to fruit. This has not been verified in replicated field tests. In several recent tests, 180 to 240 pounds per acre (201–268 kg/ha) of N produced maximum marketable yields. In fields harvested over a prolonged period (more than a month), somewhat higher seasonal rates may be justified.

INTEGRATED PEST MANAGEMENT

(Detailed information about IPM for bell pepper is available by contacting the UC IPM World Wide Web site at [http://www.ipm.ucdavis.edu](http://www.ipm.ucdavis.edu). Herbicides, insecticides, and fungicides should always be used in compliance with label instructions.)

Weed management. Control of annual and perennial weeds is a serious problem in pepper production. Nearly all non-fumigated fields are treated with preplant or preemergence herbicides or both; mechanical cultivation and hand-hoeing are usually also required to achieve acceptable control. Since pepper shows slow early-season growth and the choice of selective herbicides is extremely limited, fields with heavy weed infestations should be avoided.

Insect identification and management. A wide variety of insect pests can cause severe damage to pepper plantings. Flea beetles (Eptitrix and Phyllostreta spp.), cutworms (Agrotis and Peridroma spp.), and wireworms (Limonius spp.) are common seedling pests that periodically require control measures. Later in the season, aphids (Myzus persicae) can build to damaging levels; more importantly, they serve as vectors for several serious virus diseases. Beet armyworm (Spodoptera exigua) and tomato fruitworm (Heliothis zea) can damage foliage as well as fruit. Pepper weevil (Anthonomus eugenii) can be a serious pest of pepper fruit; damaging weevil populations are generally confined to Southern California. Leafminer (Liriomyza spp.) is not a serious primary pest in pepper but can build to populations sufficient to defoliate plants where heavy use of broad-spectrum insecticides (used for control of other pests) destroy the complex of beneficial insects that usually keep leafminer populations in check.

Disease and nematode identification and management. Phytophthora root rot (P. capsici) is widely distributed in California pepper-growing regions. Disease severity is enhanced by excessive soil moisture, with plant symptoms concentrated in low areas, at the end of furrow-irrigated fields, or in areas of restricted internal drainage. There are no effective chemical control measures; control depends primarily on proper irrigation management. Genetic tolerance to Phytophthora root rot is now available in some recently released hybrid varieties. Peppers are susceptible to infection by Verticillium wilt (V. dahliae), but serious economic loss to that pathogen is rare.

There are several potentially damaging foliar pathogens of pepper. Bacterial spot (Xanthomonas campestris), which can be seedborne or may overwinter in crop residue in soil, can be severe in warm, wet conditions. Luckily, extended wet conditions are rare in California pepper production areas, so bacterial spot is
not a major field problem. In special circumstances (greenhouse production of transplants or extended wet weather), chemical control may be needed. Powdery mildew (Leveillula taurica) has only recently been found on pepper in California, but some severe, defoliating outbreaks have occurred. Until more information is developed on this disease on pepper, a chemical control program should be initiated at the first sign of disease.

Viruses are the most damaging pepper disease problem. The major aphid-vectored viruses are cucumber mosaic virus (CMV), pepper mottle virus (PeMV), tobacco etch virus (TEV), and potato virus Y (PVY). Occurring alone or in combination, these viruses can devastate whole fields; however, their appearance and severity are unpredictable. Insecticide applications are generally ineffective in controlling these viruses since infection is frequently caused by the feeding of transient, winged aphids; insecticides may be marginally beneficial in controlling subsequent in-field spread of the viruses by colonizing aphids. Alfalfa mosaic virus (AMV) is relatively common in California pepper fields but does not often cause significant yield loss. Curly top virus, a disease vectored by the beet leafhopper (Circulifer tenellus), is generally confined to the Central Valley and seldom causes serious economic losses. Tobacco mosaic virus (TMV), historically a serious pepper disease, is now controlled primarily by the use of resistant varieties. Significant losses still occur periodically where particularly virulent TMV strains are present.

Soilborne pests of significance include the root knot nematode (Meloidogyne spp.). Root knot nematode is a problem only in relatively sandy soils where preceding crops were good nematode hosts. Field selection, crop rotation, and soil fumigation are nematode control strategies. Several abiotic disorders can cause severe damage. Blossom end rot, a calcium deficiency in the developing fruit, is seldom directly caused by a lack of soil calcium; more often, moisture stress or heavy N fertilizer applications induce a transient calcium deficiency. Pepper spot, (sometimes called pepper stip), a disorder in which fruit develop small, discolored spots as they mature, occurs mostly in fields maturing in cool weather; it is thought to also be related to calcium nutrition. Control is primarily through the use of resistant varieties.

**HARVESTING AND HANDLING**

Most bell peppers are harvested green, before the development of the mature color (red, yellow, etc., depending on variety), although a substantial fresh market has developed for colored peppers. It is common for both green and mature fruit to be harvested from the same field. The decision of what maturity to harvest depends on current market price. Processing uses (freezing, dehydrating, etc.) provide a secondary market for bell pepper, particularly colored fruit; substantial acreage is also grown specifically for processing.

Fields are harvested two to four times at 10- to 15-day intervals. Nearly all bell pepper is harvested by hand, usually into bulk bins or trailers for transit to a packing facility. A limited number of growers pack peppers in the field from mobile packing platforms. The fruit are graded by size and condition. The standard unit of sale is a 1½ bushel (0.45 hl) carton holding approximately 26 to 28 pounds (11.8–12.7 kg) of fruit; some growers of specialty sweet peppers pack fruit in smaller cartons.

**POSTHARVEST HANDLING**

To improve postharvest quality, peppers are cooled before shipment or storage either by hydrocooling (before packing) or forced-air cooling (after packing). Peppers are sensitive to chilling injury below 45°F (7°C); typical transit and storage conditions are 45° to 55°F (7° to 13°C), with high humidity (90–95% is ideal). Senescence of peppers is hastened by exposure to ethylene, so storage with ethylene-producing fruit is not recommended.

**MARKETING**

Cartons are palletized, then shipped, primarily by truck, to terminal markets or wholesale receivers across the United States and Canada. Export of fresh bell peppers from California is rare.