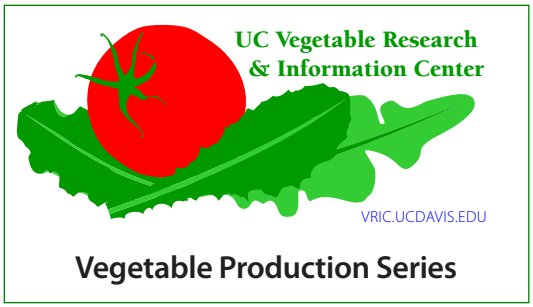

BELL PEPPER PRODUCTION IN CALIFORNIA

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PRODUCTION AREAS AND SEASONS

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

Fields in the southern desert valleys are transplanted in January or February for harvest from late April through June. In Ventura County planting occurs in April and May for harvest from July through October. Along 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. For fall production in the southern desert valleys, fields are transplanted in August for harvest from October to December.

BELL PEPPER ACREAGE AND VALUE

Year	Acreage	Average yield (tons/acre)	Gross value/ acre
2004	19,000	20.0	$11,460
2005	23,000	18.5	$10,420
2006	28,000	16.5	$10,220

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

CLIMATIC REQUIREMENTS

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

VARIETIES AND PLANTING TECHNIQUES

A wide range of varieties are grown for both fresh market and processing. These include varieties with the traditional "blocky" 3- or 4-lobe shape as well as longer, more pointed varieties known as European Lamuyo types. Small acreages of specialty "colored" peppers (mature fruit color other than red) are also grown. Both hybrid and open-pollinated varieties are used, with the trend toward greater use of hybrids. Where hybrids are used, high seed cost mandates transplanting rather than direct seeding; open-pollinated varieties can be either transplanted or seeded in the field.

In the southern desert valleys and the coastal districts peppers are commonly grown using fumigation, plastic mulch, and drip irrigation. Peppers for fresh market may also be staked for support, particularly in fields to be harvested at mature fruit color. These practices maximize earliness and yield and help compensate for the high cost of land and water, particularly in the coastal areas. No support or mulch is used for processing peppers. Elsewhere in the state, neither fumigation nor plastic mulching is common, although individual growers may utilize them. Bed width varies from 30 to 72 inches (0.75 to 1.8 m), with one or two rows of plants per bed; in-row plant spacing ranges from 8 to 16 inches (20 to 40 cm). Where direct seeding is done, 0.5 to 2 pounds of seed per acre (0.6 to 2.2 kg/ha) is used. Higher rates are used early

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in the season when soil temperature is suboptimal; pepper seed germinates slowly and erratically below 68°F (20°C).

Greenhouse production of bell pepper is common in Europe, Canada, and Mexico. In California greenhouse production is still rare, but it likely to expand in coming years. Production under shade cloth is already an established technique in the southern desert.

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 half of bell pepper acreage is drip irrigated, and the use of drip is increasing. Most drip systems employ lines buried 2 to 10 inches (5 to 25 cm) deep, with either one or two drip lines per bed. The irrigation requirement is determined by weather-based reference evapotranspiration (ET_o) 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 it 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 development can induce blossom end rot, a physiological disorder. 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 to 224 kg/ha) of P_2O_5 is common; the higher rates are generally used on early-spring plantings or in strongly alkaline soils (> 7.5 pH). Many California soils have adequate potassium (K), but in some areas K deficiency may be encountered. Soils with ammonium acetate extractable K less than 150 ppm should be fertilized with K; appropriate seasonal rates vary from 50 to 150 pounds per acre (56 to 168 kg/ha) of K_2O, 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; a late season water-run application can also be used.

Nitrogen fertilization rates tend to be very high, with many growers using more than 250 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, which have shown that 180 to 240 pounds per acre (201 to 268 kg/ha) of N is normally sufficient to produce maximum marketable yield. In fields harvested over a prolonged period (more than a month), somewhat higher seasonal rates may be justified.

INTEGRATED PEST MANAGMENT

Detailed information about IPM for bell pepper is available in the UC IPM Pest Management Guidelines for Peppers, http://www.ipm.ucdavis.edu/PMG/selectnewpest.peppers.html. 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 nonfumigated fields are treated with preplant or preemergence herbicides, or both; mechanical cultivation and hand-hoeing are usually also required to achieve acceptable weed 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. Black plastic bed mulch is an aid in weed control as is drip irrigation, which reduces weed pressure by maintaining a drier soil surface.

Insect Identification and Management

A wide variety of insect pests can cause severe damage to pepper plantings. Flea beetles (*Epitrix* and *Phyllotreta* 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 important, 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. In the southern areas tomato psyllid *(Paratrioza cockerelli)* and greenhouse whitefly *(Trialeurodes vaporariorum)* may also require control measures. 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. Under these conditions damage from *Pythium* spp. may also occur. 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*), which in some fields may cause serious economic loss. Soil fumigation, or rotation with crops for which fumigation is used, aids in control of this and other soilborne pathogens.

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)*, appears periodically. It is most commonly observed in the Central Valley, although it may occur elsewhere; serious economic loss from this virus is unusual. Tomato spotted wilt virus, a disease vectored by several species of thrips, can be locally severe; its incidence has increased in recent years, particularly in the Central Valley. 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 mainly 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 to peppers. Blossom end rot, a calcium deficiency in the developing fruit, is seldom caused by a lack of soil calcium; soil moisture stress or heavy N fertilizer applications can induce a transient calcium deficiency. The incidence of pepper spot (sometimes called pepper stip), a disorder in which fruit develop small, discolored spots as they mature, appears to be increasing. Although this disorder has been linked to low calcium content in the fruit, neither soil- nor foliar-applied calcium consistently reduces the incidence of pepper spot. Effective control of this disorder is primarily through the use of resistant varieties.

HARVESTING AND HANDLING

Bell peppers may be harvested either at the immature (green) stage, or after the mature color (red, yellow, etc., depending on variety) develops. In Ventura County and the southern desert valleys most fields are harvested at the mature color stage. Elsewhere it is not uncommon 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 typically harvested multiple 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 carton holding approximately 26 to 28 pounds (11.8 to 12.7 kg) of fruit. Some growers of specialty bell 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 to 95%). Senescence of peppers is hastened by exposure to ethylene, so storage with ethylene-producing fruit is not recommended.

MARKETING

Cartons are palletized, cooled and 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.

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