VEGETABLE RESEARCH AND INFORMATION CENTER

Vegetable Production Series

CHILE PEPPER PRODUCTION IN CALIFORNIA

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PRODUCTION AREAS AND SEASONS

California has four main chile (hot) 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 (Tulare, Fresno, and San Joaquin Counties).

Nearly all fields in the southern desert valleys are transplanted in late 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 Fresno County in February under plastic tunnels and hot caps. Plantings in the counties to the north continue over the next four months for harvest from late May to November.

CHILE PEPPER ACREAGE AND VALUE

Year	Acreage	Average yield (*tons/acre*)	Gross value / acre
1996	6,475	5.10	$4,231
1995	3,292	8.04	$5,255
1994	6,395	14.69	$4,360

Source: California Agricultural Statistics 1996 (Sacramento: California Department of Food and Agriculture, 1997).

CLIMATIC REQUIREMENTS

Chile peppers are warm-season crops, sensitive to freezing temperatures at any growth stage. The rate of seed germination decreases rapidly when soil temperatures are below 77°F (25°C), with germination below 68°F (20°C) exceedingly slow. Day temperatures of 75° to 85°F (23.9° to 29.4°C) with night temperatures about 50° to 60°F (10° to 15.6°C) are ideal for growth. Although tolerant of temperatures of about 100°F (37.8°C), such extreme conditions can reduce effective pollination, fruit set, and yield.

VARIETIES AND PLANTING TECHNIQUES

Varieties. Chile peppers comprise five species of peppers in the genus *Capsicum* and include a wide variety of pepper types. The species *annuum*, however, is the most commonly cultivated. The fruits of *C. annuum* range in size and shape from small cherry-like fruits to conical forms to slender fruits up to 9 inches (23 cm) long, and they range from mild to extremely pungent. Pungency is measured by the Scoville heat index. Relatively mild chile types like Anaheim peppers may rank as low as 500 Scoville heat units while habanero peppers rank at over 300,000. Pungency is due to the presence of capsaicin, a colorless, odorless alkaloid that is concentrated in the placental tissue.

Common chile pepper groups and varieties include the following. **Paprika**: These peppers are used for dehydration and processing and as a source of red pigment and flavoring. They are dark red at maturity and have no pungency, are 6 to 8 inches (15 to 20.5 cm) long, and are conical in shape. Several varieties are available from commercial seed companies. **Jalapeño**: These peppers are often harvested as green fruit that is sold for fresh-market use. A sizeable amount of the production is also sold to processors. **Anaheim** or **New Mexican**: These are long, cylindrical peppers 7 to 9 inches (18 to 23 cm) long. They are harvested green for fresh use as well as canning. They are also harvested red, in which case they are dehydrated and ground into powders for use in sauces. They range from varieties that have little pungency (NuMex Conquistador and Anaheim) to varieties that have appreciable pungency (e.g., Sandia). **Wax**: These peppers are referred to as wax pod types because of their shiny pod appearance. Pods vary greatly in size and shape and are usually yellow in color when immature. They can be sweet or pungent and are used fresh or for pickling. Wax types are also called Guerro, Banana, and Hungarian Wax. Varieties include Caloro, Floral Gem, Matador, Sweet Banana, and Santa Fe Grande.

A large number of other chile pepper varieties exist, including Fresno, Thai, California (dried Anaheim), ser-

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rano, poblano, and many others. There are also varieties belonging to the other species of *Capsicum*. Varieties of the species *C. chinense* include habanero, Scotch bonnet, and rocotillo; *C. frutescens* includes the tabasco pepper; *C. pubescens* includes the rocoto and mansano chiles that prefer cooler weather; and *C. baccatum* includes aji types (e.g., Aji Amarillo), which are occasionally canned into a product called chileno for niche markets.

Planting. Nearly all fields in the southern desert valleys and southern coastal regions are transplanted, as are most fields in the southern half of the Central Valley. Large fields for processing are commonly direct-seeded. Many chile pepper types are open-pollinated varieties. Hybrid varieties such as the jalapeño variety Mitla have seed that is substantially more expensive, which necessitates transplanting.

In the southern desert valleys and southern coastal areas, peppers are usually grown as double rows on raised beds, 60 to 72 inches (1.5 to 1.8 m) wide, with plastic mulch and drip irrigation. Much of the acreage is fumigated before transplanting. These three practices promote earliness and yield, and in the southern coastal areas, help compensate for the high cost of land and water. In Fresno County chile peppers are grown on beds 36 to 40 inches (0.9 to 1.0 m) wide with one seedline, or beds 60 inches (1.5 m) wide with double rows. Plastic tunnels or hotcaps are used to give early season frost protection. Elsewhere in the state, neither fumigation nor plastic mulching are common, and a wide variety of field configurations are used. Bed width varies from 30 to 66 inches (0.8 to 1.7 m), with one or two rows of plants per bed; in-row plant spacing ranges from 8 to 16 inches (20.5 to 40.5 cm). Where direct seeding is done, 0.5 to 2 pounds per acre (0.6 to 2.2 kg / ha) of seed 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 chile 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 saturated from excessive irrigation or rainfall.

IRRIGATION

Statewide, approximately 25 percent of chile pepper acreage is drip-irrigated. Many drip systems employ lines buried 2 to 10 inches (5 to 25.5 cm) deep, with either one or two drip lines per bed; however, a large number of growers also place the tape on the surface of the soil to improve root development and ease removal and installation of the tape. The irrigation requirement is best determined by weather-based reference evapotranspiration (ET) 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 majority of California chile 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, 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

Chile peppers require moderate to high rates of fertilizer. 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 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 to 168 kg / ha) of K_2O, depending on soil test values.

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 fertigations throughout the season. In conventionally irrigated fields, N and K are applied preplant and in one or more sidedressings; late season water-run applications are also common.

Nitrogen fertilization rates tend to be high, with many growers annually using more than 250 pounds per acre (280 kg / ha). It is a widespread belief that high N rates increase plant vigor, foliage cover, and fruit size, which in turn increases yield and decreases sunburn damage to fruit. However, replicated field tests have generally shown that maximum yields can be achieved with 150 to 200 pounds per acre (168 to 224 kg / ha) of N. In fields harvested over a prolonged period (more than a month), somewhat higher seasonal rates may be justified.

For information on critical levels of nutrients in the soil and pepper plant tissue, refer to *Soil and Plant Tissue Testing in California*, DANR Publication 1879.

INTEGRATED PEST MANAGEMENT

Detailed information about IPM for peppers is available by contacting the UC IPM World Wide Web site at http://ww.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. Many nonfumigated fields are treated with preplant or preemergence herbicides, depending upon the weed spectrum; mechanical cultivation and hand-hoeing are usually also required to achieve acceptable control. Since peppers grow slowly in the early part of the season, 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 significant 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* spp.) can build to damaging levels; more importantly, they serve as vectors for several serious virus diseases. Beet armyworm *(Spodoptera exigua)* and tomato fruitworm (*Heliocoverpa 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 trifolii*) can build to populations sufficient to defoliate plants. Heavy use of broad-spectrum insecticides (used for control of other pests) destroys the complex of beneficial insects that usually keep leafminer populations in check. A comprehensive IPM program using insecticides that do not disrupt beneficial populations can minimize this problem.

Disease and nematode identification and management. Phytophthora root rot (*Phytophtora 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 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 (*Verticillium dahliae*), and occasional serious economic loss to that pathogen occurs.

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, may be severe in warm, humid conditions. 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, and some severe, defoliating outbreaks have occurred. Until more information is developed on this disease, a chemical control program should be initiated at the first sign.

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 entire fields, and their appearance and severity are unpredictable. Insecticide applications are generally ineffective in controlling viruses since infection is 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 stip causes greenish-brown spots that are about ¼ inch (6.5 mm) in diameter on the fruit. They are most commonly seen on the mature red fruit but occasionally occur on green fruit as well. It is not clear as to the cause of pepper stip, however, resistant varieties offer the most successful control.

HARVESTING AND HANDLING

Many chile peppers are harvested green, before the development of the mature color. However, some chile types, such as paprika and Anaheim, are harvested in the mature red color. There are many industrial uses for the red pigment that paprika possesses. A large percentage of the chile peppers in California are harvested

for processing into salsas and canned whole. The remainder are harvested for the fresh market.

Fresh-market fields are harvested two to four times at 10- to 15-day intervals, while processing fields are picked once or twice. Nearly all chile peppers are harvested by hand, usually into bulk bins or trailers for transit to a packing or processing facility. Mechanical harvesters for processing chile peppers are used to a limited extent.

POSTHARVEST HANDLING

Harvested chile peppers may be washed with water containing 75 to 100 ppm chlorine. Excess water should be removed. To improve postharvest quality, fresh-market chile peppers should be cooled before shipment with room cooling or forced-air cooling. Ideal transit and storage conditions are 45° to 50°F (7.2° to 10°C) with high relative humidity (90 to 95%). When held at the proper temperature and humidity, the storage life is 2 to 3 weeks. Storage temperatures warmer than 50°F (10°C) favor color change (ripening). Chilling injury occurs at temperatures below 45°F (7.2°C). Chilling damage will be expressed as surface pitting, discoloration of the fruit, and excessive decay. Top ice is not recommended on chile pepper boxes. Deterioration and/or color change of chile peppers is more rapid with exposure to ethylene, and storage with ethylene-producing fruit is not recommended.

MARKETING

Chile peppers are marketed for the fresh market and for processing. Fresh market containers include half-bushel boxes and 10- to 20-pound food-service cases. Processed chile peppers are picked into bins and transported to processing plants for canning, brining, freezing, and drying.

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