



CABBAGE PRODUCTION IN CALIFORNIA

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PRODUCTION AREAS AND SEASONS

The main growing regions for cabbage (*Brassica oleracea* L. var. *capitata* L.) in California are the central coast (Monterey, San Benito, and Santa Clara Counties); southern San Joaquin County; the southern coast (Santa Barbara, Ventura, San Luis Obispo, Los Angeles, Orange, and San Diego Counties); and the southern desert (Imperial and Riverside Counties).

In the southern desert (Imperial Valley), cabbage is planted from mid-September through October. Harvesting begins in December and continues through February. In many coastal counties cabbage is planted and harvested year-round. Cabbage is planted in the southern San Joaquin Valley in August for harvest in October and November. In Chula Vista, near San Diego, cabbage is planted from September to March for harvest from November to June.

The average yield, which varies according to market price, can be more than 1,000 cartons per acre (2,470 per ha). Harvested yields normally reflect market demand rather than actual crop yield: if prices are too low, much of the harvestable crop is left in the field.

Cabbage is a high-risk crop: oversupply from competing markets can depress prices rapidly, and a shortage in the cabbage supply can create windfall profits. Some cabbage is grown under contract with fast-food outlets and coleslaw manufacturers at a fixed volume and price.

FRESH MARKET CABBAGE ACREAGE AND VALUE

Year	Acreage	Average yield (ton/acre)	Gross value/acre
2006	13,800	22.0	\$5,800
2005	13,300	17.5	\$5,285
2004	13,600	20.5	\$7,380
2003	13,500	19.5	\$6,240

Source: *California Agricultural Resource Directory 2007* (Sacramento: California Department of Food and Agriculture, 2007).

CLIMATIC REQUIREMENTS

Cabbage is a cool-season biennial that is grown as an annual vegetable. It has a moderately high frost tolerance. While cabbage will grow at 45°F (7°C), it does best from 60° to 65°F (15.5° to 18°C). Above 80°F (27°C), the plants may bolt, causing the heads to split open. Cabbage seed germinate in about 2 weeks in soils with temperatures as low as 50°F (10°C), which allows for early plantings in cooler regions.

VARIETIES AND PLANTING

The standard green hybrids are Headstart, Pacifica, Discovery, Grenadier, Charmant, Grandslam, and Supreme Vantage. Red hybrids frequently used are Rubyball, Primero, Sombrero, and Red Rookie. Open-pollinated Red Meteor is also used.

Cabbage is grown in two plant lines on 42-inch (105-cm) beds. Growers plant seed using a precision planter with an in-row spacing of 2 to 3 inches (5 to 7.5 cm) at a depth of 0.25 inch (0.6 cm) or less, with seed lines 13 inches (33 cm) apart. At this spacing, about 156,000 seeds are planted per acre. Seedlings are thinned to 12 to 14 inches (30 to 35.5 cm) apart when they develop 2 to 3 true leaves. Some cabbage grown in the central coast and most in the south coast is transplanted from nursery-grown plugs with two lines on 40-inch (1-m) beds, with rows spaced 12 to 14 inches (30 to 35.5 cm) apart.

SOILS

Cabbage may be grown on many soil types. Silty clay soils unsuitable for lettuce, carrots, or onions produce excellent cabbage crops. Cabbage grows well on medium and moderately heavy soil and is not sensitive to poor drainage. Some problems may occur late in the season on sandy soil if wind causes sand damage (callus tissue) on the outer leaves on the heads. Cabbage is moderately salt-tolerant: yields are near 80 percent



of maximum with ECe (electrical conductivity of saturated paste) of 4 mmhos/cm (4 dS/m) and an ECw (electrical conductivity of water) of 2.5 mmhos/cm (2.5 dS/m).

IRRIGATION

Most growers use solid-set or hand-move sprinklers to germinate seed or establish transplants. After the first cultivation and sidedressing of fertilizer, growers often switch to furrow or surface drip for the remainder of the season. Sprinklers are most often used for full-season irrigation of cabbage on the central coast in areas such as Monterey and Santa Cruz Counties. Southern coast counties such as Ventura commonly establish transplants with sprinklers and switch to surface drip after establishment, and southern desert counties (Imperial) typically use furrow irrigation after the first cultivation. Cabbage plants can tolerate moderate water stress early in the season, but later, when heads are sizing, excessive water deficit may cause heads to split.

The water requirements of cabbage depend on the irrigation method, weather conditions, and soil type. Depending on the initial soil moisture conditions, 2 to 6 inches (5 to 15 cm) of water is often applied before planting to moisten soil for tillage and bed preparation. After planting, approximately 1.0 to 1.5 acre-feet (1,238 to 1,857 m³) of water per acre is applied to germinate and grow cabbage, using a combination of overhead sprinklers and drip; 1.5 to 2.0 acre-feet (1,857 to 2,476 m³) is applied per acre when overhead sprinklers are used for the entire crop. As much as 3.0 acre-feet (3,714 m³) is applied for cabbage produced under furrow irrigation in the southern desert counties.

The combination of soil moisture monitoring and weather-based irrigation scheduling can be used to determine the water needs of cabbage. Water use is highest during the last month of the crop when vegetative growth is high. Soil moisture tensions are typically targeted for less than 30 to 45 cbars (30 to 45 kPa) during this period. Water extraction of cabbage can be estimated using reference evapotranspiration data adjusted with a crop coefficient that is closely related to the percentage of ground covered by the canopy. At a maximum canopy cover of 85 percent, the crop coefficient is nearly 1.0. The California Irrigation Management Information System (CIMIS, www.cimis.water.ca.gov), coordinated by the California Department of Water Resources provides daily estimates of reference evapotranspiration for most production regions of California.

FERTILIZATION

In the southern desert growing areas, before listing the beds growers usually broadcast ammonium

phosphate (11-52-0) at 200 pounds per acre (224 kg/ha) P₂O₅. Sidedress applications of nitrogen (N) at 60 to 80 pounds per acre (67 to 90 kg/ha) are standard. Solutions of AN-20 (ammonium nitrate, 20-0-0) or UAN-32 (urea-ammonium nitrate, 32-0-0) may be used instead of dry nitrogen fertilizers.

In coastal growing regions, growers apply 500 pounds per acre (560 kg/ha) of a complete fertilizer (15-15-15) before planting. When the plants have five to six true leaves, they direct-spray nitrogen at 130 pounds per acre (145 kg/ha) as ammonium nitrate solution (20-0-0) to fertilize the crop and burn down weeds. At midseason they apply 60 pounds of nitrogen per acre (67 kg/ha) as liquid ammonium nitrate or calcium nitrate solution (17-0-0) to carry the crop to maturity.

INTEGRATED PEST MANAGEMENT

For detailed information about integrated pest management for cabbage, see the UC IPM Pest Management Guidelines for Cole Crops Web site, <http://www.ipm.ucdavis.edu/PMG/selectnewpest.cole-crops.html>. Herbicides, insecticides, and fungicides should always be used in compliance with label instructions.

Weed Management

Preemergence and post-transplant herbicides such as oxyfluorfen or trifluralin are fairly effective at controlling annual weeds in cabbage, with the exception of London rocket, shepherd's purse (*Capsella bursa-pastoris*), and weeds with wind-dispersed seed. Hand-weeding and cultivation between rows are often necessary to remove weeds. Yellow nutsedge (*Cyperus esculentus*), a common perennial weed in Southern California, is particularly difficult to manage since no selective herbicides are currently available for nutsedge control in cabbage. Avoid heavily infested fields; rotate to crops for which effective herbicides or fumigants are available to control yellow nutsedge.

Insect Identification and Control

Insect pests of cabbage include crickets, cutworms, flea beetles, saltmarsh caterpillars, aphids, silverleaf whitefly, beet armyworm, diamondback moth, and cabbage looper. Once an insect burrows into a cabbage head, the head is not marketable. Insecticides must be applied early for stand establishment and during head development to prevent economically important damage. In coastal areas, the cabbage aphid (*Brevicoryne brassicae*) is the most important pest. In the southern deserts, turnip aphid (*Hyadaphis erysimi*) and green peach aphid (*Myzus persicae*) are more common pests. Several predators and parasites attack aphids, especially in fields that are not sprayed or sprayed with less-toxic materials. These natural enemies, includ-

ing general aphid predators such as the seven-spotted lady beetle (*Coccinella septempunctata*) and the parasites *Lysiphlebus testaceipes*, *Aphidius matricariae*, *Aphelinus semiflavus*, and *Diaeretiella rapae*, may provide adequate control under certain circumstances. In the southern deserts, the silverleaf whitefly (*Bemisia argentifolii*) causes slow growth and delayed maturity of the crop. In all production areas, several worm pests such as loopers (*Trichoplusia ni* and *Autographa californica*), imported cabbage worm (*Pieris rapae*), beet armyworm (*Spodoptera exigua*), diamondback moth (*Plutella xylostella*), and others are potential problems depending on the time of year and weather conditions. Worms should be managed by using selective materials to avoid making other insect problems more severe. Rotation of insecticide classes is essential for insecticide resistance management. Concerns of resistance to new-generation pesticides are present whenever one chemical is heavily relied upon as a control measure.

Disease Identification and Management

There are very few troublesome diseases of cabbage in California. Downy mildew (*Peronospora parasitica*) may require control if moist, cool conditions persist. Wirestem (*Rhizoctonia solani*) may cause seedling losses at times in wetter growing regions. White mold (*Sclerotinia sclerotiorum*) may occasionally cause a head rot of cabbage.

Other Pests and Problems

Cabbage should not be planted after sugar beets if high populations of cyst nematode (*Heterodera schachtii*) are present. Edema is a physiological disorder of cabbage that causes blisters and callus eruptions on the epidermis of the leaves. It is caused by overwatering, especially during cloudy, humid weather. Tip burn, a physiological disorder caused by low calcium in the tissues, may cause substantial loss of marketable heads. Plants without a growing point (normal meristem) are called "blind." Blindness may be caused by mechanical damage, bird and insect feeding, or genetic defects. Blind plants have abnormal older leaves and never form a marketable head.

HARVESTING AND HANDLING

Cabbage is harvested by hand. From 18 to 24 heads are bulge-packed per carton, which weighs a minimum of 45 pounds (20 kg). Because head counts can vary, many sales are made on the basis of net weight. Cabbage is normally sold by the pound at retail stores. Limited amounts of cabbage may be packed in bins for reprocessing into coleslaw or shredded salad mixes or contracted to fast-food chains. Cone-shaped cabbage heads are not acceptable in markets on the West Coast and in the Pacific Northwest but are accepted in some Eastern and Midwestern markets.

POSTHARVEST HANDLING

Cabbage may be cooled by hydrovac, vacuum cooling, or in non-forced-air cooling rooms. Cabbage should be refrigerated after cooling and stored at 32°F (0°C) at 98 percent relative humidity. Storing at low humidity causes wilting and senescence. Cabbage is sensitive to ethylene gas; if it is stored near ripening fruits, loss of green color and abscission of leaves will result.

MARKETING

California ships cabbage every month of the year. Shipments from California are highest in March and relatively lower from December to February. During the winter, California cabbage competes with production from Texas, Georgia, and New York. A dozen or more states ship cabbage in the late spring, summer, and early fall. California exports about 15 percent of its total cabbage production to other countries, predominantly to Canada.

COSTS OF PRODUCTION

The cost of cabbage production depends on location, since inputs such as water, land lease, fertilizer, pesticides, etc. depend on local climatic conditions and soil properties. Generally, cabbage production is labor-intensive, especially in harvesting and post-harvest handling. For more information, see *Sample Cost to Establish and Produce Cabbage, Imperial County, 2004*, at the the UC Davis Agriculture and Resource Economics Web site, <http://ucce.ucdavis.edu/files/filelibrary/5600/42616.pdf>.

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